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U.S. DEPARTMENT OF AGRICULTURE/Agricultural Marketing Service/Transportation and Facilities Research Division

Marketing Research Report No. 665

THREE METHODS for LOADING OUT PRODUCE in WAREHOUSES

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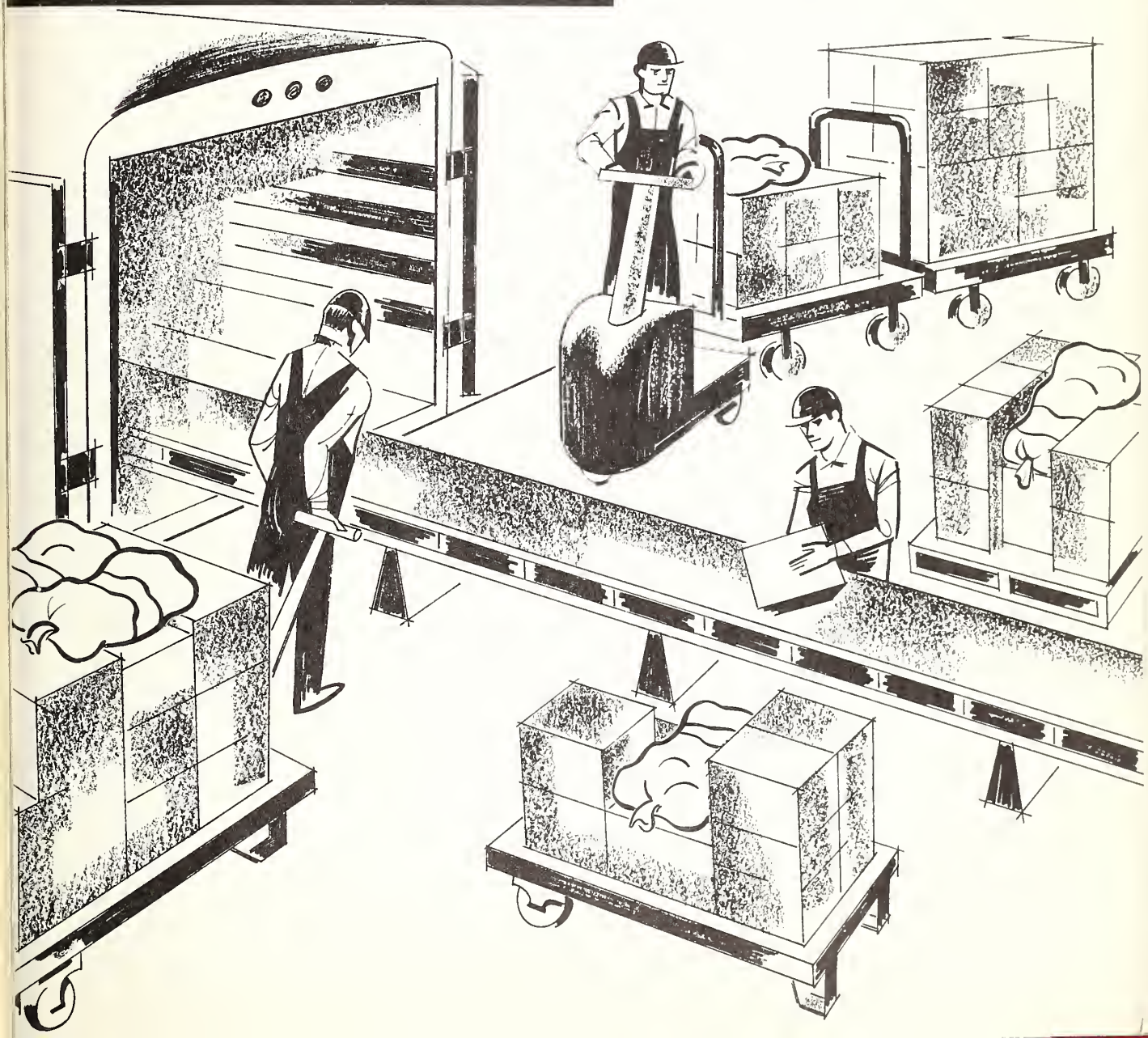

PREFACE

This study of selected methods for assembling merchandise and loading delivery trucks with produce in wholesale warehouses is part of a broad program of research by the Agricultural Marketing Service aimed at reducing costs and increasing efficiency of food wholesaling and retailing. More efficient use of labor and equipment achieved in any part of the broad research program may form a sound basis for an increase in labor wage rates, as well as an increase in the farmers' price, and a decrease in the cost of food to the consumer. This report up-dates, in part, Marketing Research Report No. 282, Loading Out Fruits and Vegetables in Wholesale Warehouses. Of related interest to readers are MRR-478, Receiving Fruits and Vegetables in Wholesale Warehouses, and MRR-622, Storing Fruits and Vegetables on Pallets in Wholesale Warehouses.

Food distributors look to the warehouse as a place to reduce operating costs. For this reason, and because wholesale produce distributors would like to know which method of assembling orders and loading delivery trucks is most efficient, this research was undertaken.

Trade names are used in this report to describe the equipment observed. This use does not constitute endorsement of the equipment by the U.S. Department of Agriculture or imply discrimination against any other equipment.

The authors wish to thank the three firms selected to represent different methods of assembling and loading produce for making their facilities available for detailed study. The study was conducted under the general direction of R. W. Hoecker, William H. Elliott, and Joseph F. Herrick, Jr., who are Chief, Wholesaling and Retailing Research Branch; and Chief, and Marketing Research Analyst, of the Handling and Facilities Research Branch, respectively, of the Transportation and Facilities Research Division. Robert K. Bogardus, industrial engineer, participated in planning the research and conducting field studies before he resigned from the Handling and Facilities Research Branch.

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SUMMARY

This study compares labor and equipment costs to assemble, select, and load in produce warehouses. Three methods are evaluated. With each method, similar varieties and sizes of fresh fruits and vegetables are handled, and the same average tonnage is shipped daily.

Method A, the slot system, used one or two selector trucks pulled by a towtractor through the storage area. Packages were obtained from warehouse location (slots) according to order, and placed on a truck by the operator of the towtractor. Filled trucks or completed orders were taken to the dock for loading. Method A was generally used by the affiliated food distributor who supplied retail stores with a complete line of food products including groceries, produce, frozen foods, and meats. Mixed loads of these foods were often shipped in the delivery trucks of the affiliated distributor. Method A proved least costly for order sizes larger than 37 packages for both 1- and 2-shift operations.

Method B, the conveyor and transcriber system, used a powered belt conveyor approximately 50 feet in length, leading from an assembly area on the dock into a delivery truck. Packages were obtained from skids and positioned on the conveyor by one man who listened to a transcribing machine, and were removed and loaded in the truck by a second man. A low-lift platform truck brought merchandise on skids from storage. Method B was generally used by the service wholesaler who usually supplied produce only to independent and affiliated retail stores and institutional establishments. This method proved least costly for 1- and 2-shift operations for order sizes of 37 packages and less.

Method C, the conveyor and checker system, also used mostly in the service wholesale warehouse, had a powered belt conveyor about 100 feet long. Packages were obtained from pallets or skids in the assembly area by selectors who waited for a checker to call items. Two men loaded off the conveyor in the truck. The assembly area was replenished by using a combination of pallets with forklift truck and manual pallet jacks with skids. Method C was less costly than method A for order sizes of 27 packages and less but was more costly than method B for all order sizes.

On the basis of observed average order size, concentration of orders within order size groupings, and costs, method A, the slot system, and method B, the conveyor and transcriber system, were least costly. The firm that used the conveyor and checker system, method C, would have had lower cost if method B had been used.

Three Methods for Loading Out Produce in Warehouses

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INTRODUCTION

During the last 15 years many corporate chains, voluntary groups, and cooperative groups have built modern, one-floor food-distribution warehouses. While groceries have always been handled through such warehouses, handling of perishable foods, such as meats, bakery products, frozen foods, dairy products, and fresh fruits and vegetables has been recently added in many companies. Since operating experience of these firms, and the bulk of their business volume, have traditionally been with groceries, grocery warehouse handling methods have been applied to perishable food products. Produce handling equipment and methods used by affiliated distributors, particularly for order assembly and truckloading, are therefore different from those used by independent fruit and vegetable wholesalers who normally handle produce exclusively. Affiliated distributors include those handling a full line of food products, serving corporate chains, voluntary groups, retailer-owned cooperative groups, and consumer-owned organizations. In affiliated distribution some degree of control over retail operations is exercised by warehouse management.

The warehouse cost for handling fresh fruits and vegetables as a percentage of selling price is approximately twice as great as the cost for handling groceries. The increased cost is due, in part, to the smaller order sizes handled in assembly and loading operations and lower unit value of produce items when compared with groceries, and in part to use of traditional methods and lack of mechanization in produce warehouses. Approximately three-fourths of warehouse labor cost is incurred in order assembly and truckloading.

This research was undertaken to determine costs of assembling merchandise and loading delivery trucks of wholesale distributors of fresh fruits and vegetables using the best methods adapted from handling groceries, compared with the best handling methods used by independent fruit and vegetable wholesalers.

In the evaluations that follow, every effort is made to present each method's labor and equipment requirements and costs on an equitable basis. The following assumptions and methods are used: An average package weight of 40 pounds; comparisons on a per-ton basis; and balanced work crews (accounting for job-regulated wait time). Materials-handling cost estimates are based on equipment manufacturers' prices for 1963.

The appendix contains a description of research techniques, time-study methods, and work elements for the three methods. The appendix has tables of time requirements for different operations such as: Forklift-truck pallet letdown; merchandise selection and assembly; truckloading; and setup and cleanup. It also gives equipment requirements for each method, showing costs for each machine on annual and hourly bases. A separate table gives costs for pallets and skids on an annual and a per-ton-shipped basis.

ASSEMBLY AND LOADING

Assembly and loading of produce begins when merchandise is taken from warehouse storage to an assembly area on the dock or when merchandise is selected directly from storage into customer orders, and ends when it has been loaded in trucks ready to be transported to customers.

All of the wholesale distributors handled the same varieties and sizes of fruits and vegetables. Three methods of assembly and loading, chosen as the most efficient, are evaluated. The following description and letters are used in the report to identify them: The slot system, method A; the motorized-belt conveyor and transcriber, method B; and the motorized-belt conveyor and checker, method C. Costs for each method have been developed from data obtained in cooperating wholesalers' warehouses.

Generally, each of the methods has three major areas of activity: (1) Preparation; (2) assembly; and (3) truckloading.

Preparation includes obtaining customer orders, preparing a recapitulation (a summary of orders, by commodities) of merchandise sold, taking inventory of fruits and vegetables in storage, making forklift pallet letdowns to fill selection slots, opening warehouse doors, backing trucks to the loading dock, sweeping trucks, positioning a bridge plate between the truck floor and the dock, clearing the assembly area of materials and equipment not a part of the assembly or loading operation, lighting the truck body's interior, and routing trucks for delivery of customers' orders.

Assembly includes the bringing of merchandise from warehouse storage to an assembly area for selection or loading. Some of these activities include: Traveling with materials-handling equipment to storage bays or slots in the warehouse; locating and placing proper packages on the equipment; transporting packages to the assembly area in unit-load quantities, or in single packages in accordance with a customer invoice or a commodity recap; and removing merchandise from skids and stacking in the assembly area.[1]

Truckloading includes: (1) Moving orders assembled on selector trucks at the dock holding area into trucks, or (2) a checker or a transcribing machine giving orders, and belt loaders placing the items on a conveyor for transport into trucks; and loaders stacking packages in trucks. Different combinations of labor and equipment are used to transport packages into trucks, and one- or two-man crews are used to stack merchandise.

Checkers are not used with methods A and B. With method A, invoices are printed in slot-number sequence to agree with warehouse merchandise slot numbering. Operators' experiences with method A show that the expense to the firm for checking is greater than the expense of handling packages found to have been selected in error, and the number of customer complaints is relatively small.

With method B, which uses the group recap to assemble items for the assembly areas, the men doing the assembly work stack items in each assembly area on the basis of the recap. When the assembly operation is complete, each order assembly area has in it only those items that will be loaded on one truck. Since the identity of these packages with a particular truck is shown on the recap, a check is made of the items placed in each area. This eliminates the need for inspection of packages on the belt usually performed by a checker.

A checker is the key person with method C, the belt conveyor and checker method of assembly and loading. He calls items on order to three selectors who place items on the conveyor belt, and two men stack the items in the delivery truck.

SLOT SYSTEM, METHOD A

The slot method of assembly and loading is used extensively by affiliated produce distributors. It has been adapted from grocery warehouse handling methods and uses the same type of equipment.

[1] The assembly of less-than-full package quantities, called repack, is part of assembly that is omitted intentionally because its study is not relevant to evaluations made in the report.

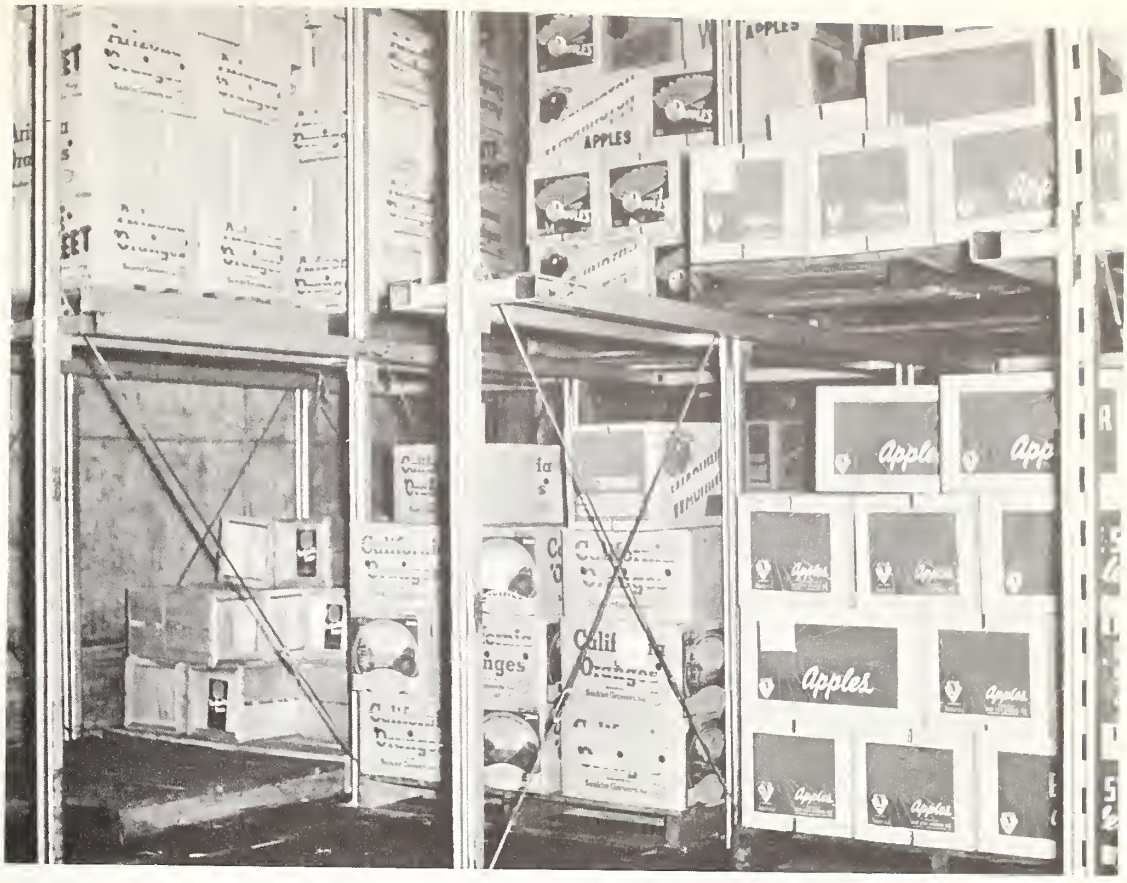

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Figure 1.--The drive-in type of produce rack used with method A. The rack shown has a depth of three pallets. Each palletload of merchandise rests on individual supports.

Description

With the slot method of assembly and loading, all merchandise is placed on pallets and is stored on racks tiered 3-high, reaching from the floor to the ceiling. With a stacking height of 20 feet that is clear of overhead pipes, sprinkler systems, and roof supports, these racks utilize warehouse cubic space effectively.[2] Each tier in a rack will hold a palletload of produce. Racks are generally of three types, drive-in, drive-through, or pallet. The drive-in rack is shown in figure 1. This is a rack into which the forklift truck operator may literally drive in for any number of pallet depths to deposit his load on one of three levels. The rack may be moved about the warehouse as circumstances require without tearing out the warehouse floor. Bracing is provided in the center of the rack. The drive-through rack, developed before the drive-in type, has the advantages of the latter plus no supports in the center; it is possible to drive a forklift through the rack from one aisle to another when it is empty. A disadvantage is that the rack must be anchored to floor and ceiling to provide bracing and support.

An outstanding advantage of both racks is that the weight of more than one pallet load of merchandise is never borne by a single pallet because separate supports are provided for each pallet.

[2] Ferris, Richard T. and Bogardus, Robert K. Storing Fruits and Vegetables on Pallets in Wholesale Warehouses. U.S. Dept. Agr. Mktg. Res. Rpt. No. 622, 38 pp., illus. Feb. 1964.

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Figure 2.--A pallet rack placed along a wall. Cubic space is not used effectively.

Where space prevents the effective use of drive-in or drive-through racks, for example, along a wall, a rack one pallet deep, called a pallet rack, is used. This type of rack is described in previous marketing research.[3] The pallet rack has been adapted by affiliated food distributors for use in produce warehouse operations. It is excellent for handling merchandise with slow turnover, but it does not utilize warehouse space as effectively as a drive-in rack, since it is not possible with the pallet rack to place more than one pallet of merchandise overhead without damage to produce by bruising because of excessive weight. A pallet rack is shown in figure 2.

Selection of packages to fill orders is from the floor-level pallet position only. Each floor-level pallet position is called a slot. Each slot is numbered. The slot numbering technique is discussed in previous marketing research.[4] A means of keeping merchandise in these slots is provided by the following procedure. When a slot becomes empty, a forklift truck operator lowers, or makes a letdown of a palletload of merchandise from reserve; that is, from an upper-level tier to fill the slot, thus making the item available to the order selector when needed on orders. Appendix table 10 gives the time requirement per pallet of produce for the forklift truck operator to make a letdown to stock the slot. Appendix table 11 gives the forklift time required per ton of produce shipped.

A commodity stored in a slot is assigned the designated slot number, and tabulating machine cards are so punched. Retail orders are made up by the tabulating equipment, which sorts and lists the commodity cards in slot number sequence. Generally, the first number in the sequence will be the start of the order selection route, and the last number will be the end of the route. Items on invoices in the warehouse selected to represent

[3] Bouma, J. C. and Lundquist, A. L. Grocery Warehouse Layout and Equipment for Maximum Productivity. U.S. Dept. Agr. Mktg. Res. Rpt. No. 348, 55 pp., illus. July 1959.

[4] See footnote 3.

method A are listed by three warehouse zones. Warehouse location of an item will not always be in exact sequence with the invoice listing, although the warehouse superintendent attempts to do this. Thus, items were assembled by reading item descriptions.

The slot method provides for storing all units of a given commodity in one location. Rack slots are usually from one to five pallets deep. The depth of slot to be used is determined by the quantity of an item that is received. For example, merchandise received in quantities of one to three palletloads is placed in one-deep pallet racks, tiered three high. Four to six palletload quantities are placed in a two-deep rack. Merchandise received in 12 pallet quantities is placed in a four-deep rack, and so on. A very fast-moving commodity, received in a carload quantity, would require from 12 to 35 palletloads to accommodate it, depending on package size, and would take from 1 to 3 adjoining slot positions in a 5-deep rack because in a 5-deep rack slot, 15 pallets of a particular item can be stored.

The assembly of individual orders constitutes a major portion of man-hours cost with method A. Assembly begins when the order selector obtains an order, and includes obtaining selector trucks, traveling to the selection area, traveling through the warehouse aisles, selecting produce packages, and marking and reading the invoice. When the order selector has filled his train of selector trucks with merchandise, he travels to the dock and drops the load. He then either continues to assemble the same order, hooking empty selector trucks to the towtractor and returning to the selection area, or he obtains the next order and starts at the beginning of the selection line. Appendix tables 15 and 16 give labor requirements for order selection using method A.

Truck loading labor requirements, the second main portion of cost with method A, are shown in appendix tables 17 through 19. Element descriptions are listed in the tables. The operation is based on an assumed total travel distance of 60 feet, from the dock into the truck and return. The operation begins when the loader starts toward a loaded selector truck for the first order and includes pushing it into the delivery truck, stacking the packages in the delivery truck, and ends when he has released the last empty selector truck on the dock after stacking all packages for the last order. There is no limit to the number of trucks that can be loaded simultaneously with method A, other than physical size of warehouse and the amount of equipment.

The company selected to represent the slot method, A, services voluntary group retailers with a minimum of two deliveries weekly with groceries, produce, frozen foods, dairy products, and frozen poultry. Produce warehouse shipments totaled $5.6 million annually. Orders ranged from 4 to 438 packages in size during the period of the study and averaged slightly less than 67 packages per order.

Equipment Requirements

Each order selector uses a standup rider-type towtractor which pulls one or two selector trucks. Figure 3 shows order selection in the company representing method A.

Each of the selector trucks pictured in figure 3 holds an average of 20 packages of produce. Order size determines whether one or two trucks are pulled per trip by the towtractor along the order selection route.

Each towtractor and each selector truck is fitted with an attachment with which it may be joined to another truck or to a towtractor. Breakup of a train is controlled by the order selector with a coupler located at the rear of the towtractor.

Each towtractor requires a battery charger. Also used is an extendable-fork lift truck(fig. 4), charger, and an extra battery. The lift truck is used to rotate merchandise, and to lower merchandise to floor level for order selections. More detailed specifications for equipment are in appendix tables 23 and 26.

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Figure 3.--An order selector using a tow tractor and two selector trucks for order assembly, method A.

Crew Size

Merchandise is assembled for shipment five nights per week on two shifts. The first shift begins work at 3 p.m. and works until midnight. The second shift begins at midnight and works until 9 a.m. An assembly and loading crew is composed of three order selectors, one forklift truck operator, and two truckloaders, a total of six men per shift. Each loader works independently so that two trucks are loaded concurrently.

MOTORIZED-BELT CONVEYOR AND TRANSCRIBER, METHOD B

This method is basically a two-part operation consisting of assembly and loading. It is used principally by service produce wholesalers who normally supply retail stores, plant and public cafeterias, and hotel dining rooms with fruits and vegetables.

Description

Dead skids and electric low-lift platform trucks are used to assemble and move packages on order from the storage area to a place near the conveyors for truckloading. Work assignments to individual assemblers are based upon use of group recaps. A group recap combines a number of truck recaps. The same method of making a truck recap is used to prepare a group recap, but rather than combining individual customer orders, the recapper works with previously prepared truck recaps. Either the blank or preprinted type of invoice is used. Figure 5 shows the recapping of orders in the firm representing

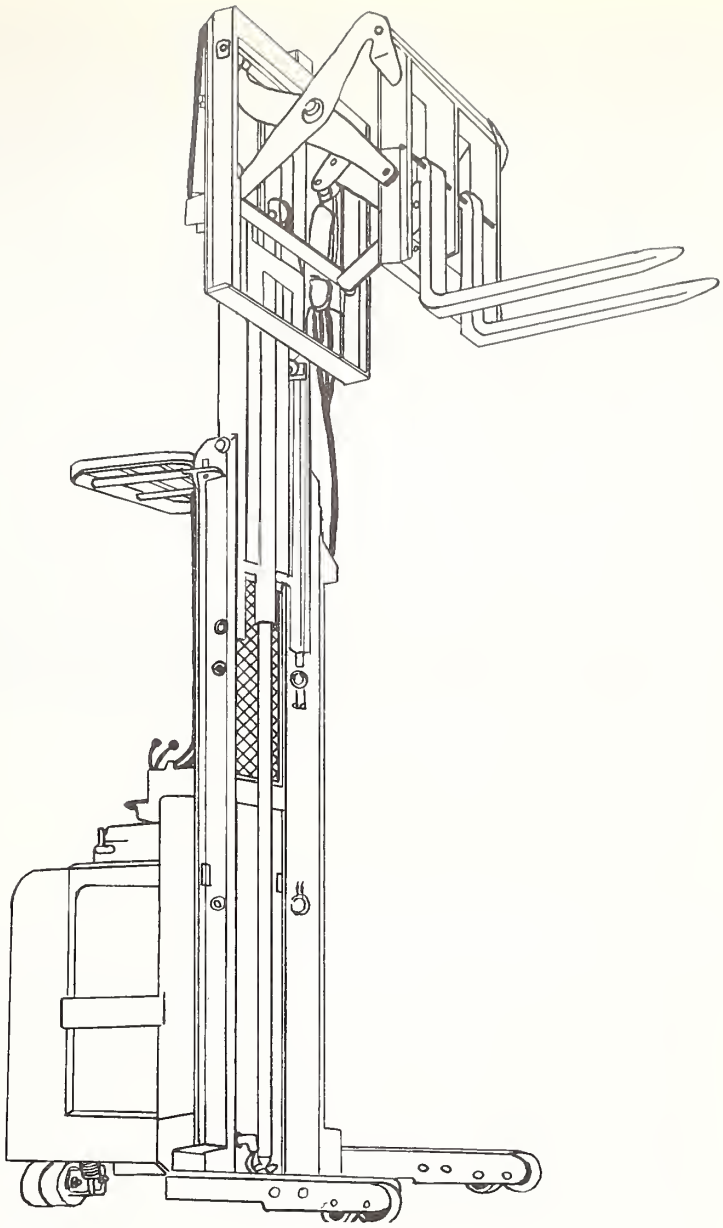

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Figure 4.--An extendable-fork lift truck, used with method A.

method B. The efficiency of the assembly operation--in fact, of the entire loading operation--depends on an accurate recap.

Each member of the assembly crew is assigned a portion of this recap. A portion may include several commodities. The operation begins when the assembler receives his part of the group recap. It includes locating a dead skid, placing it on the low-lift platform truck and transporting it to the appropriate storage area. At that point, the assemblyman loads the skid, and transports it to the order assembly areas. In the firm representing method B, there are four order assembly areas to be serviced. The assemblyman stacks as many packages of each commodity on the floor at each assembly area as the recap indicates should be placed there. In some cases, the number of packages for one assembly area may be a full skid. This cycle of activity continues until all

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Figure 5.--The recapping of orders performed in the firm representing method B.

the items listed on the recap have been assembled and stacked in each assembly area. The operation ends when the last package is placed in the last order assembly area and the lowlift platform truck is set aside for later use. Labor required per ton for assembly is shown in appendix table 14. For comparative purposes an average travel distance of 100 feet is assumed.[5]

Trucks are loaded concurrently. Each loading station utilizes two lengths of conveyor (figure 6). The longer of the two is parallel to the dock and against a warehouse outer wall, leaving one side of the conveyor available for loading. The shorter section is an Expandoveyor unit of 15 feet, expandable to 25 feet. It is perpendicular to the truck dock. An electric motor drive is geared to the conveyor, and the conveyor is moved in and out of the truck by electric power.

Each truckloading station has a 2-man crew, a transcribing machine, and a set of speakers.[6] The man assigned to place packages on the conveyor belt pulls a cord which starts the transcriber. This is shown in figure 7. When he has heard as many items as he can remember, he releases the cord. This stops the transcriber. The man then selects the packages and places them on the belt. This cycle of starting and stopping the transcriber and placing packages on the belt is repeated until the truck is loaded. The other crew member loads packages in the truck, taking them from the truck end of the conveyor (fig. 8). Labor required per ton to select and load with method B is shown in appendix table 20.

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[5] Bogardus, Robert K. and Burt, S. W. Loading Out Fruits and Vegetables in Wholesale Warehouses. U.S. Dept. of Agr. Mktg. Res. Report No. 282, 53 pp., illus. March 1959.

[6] Kercho, M. R., Herrick, J. F., Jr., and Burt, S. W. Use of Recording and Transcribing Equipment in Loading Delivery Trucks of Produce Wholesalers. U.S. Dept. Agr. Inform. Bul. No. 43, 20 pp., illus. May 1951.

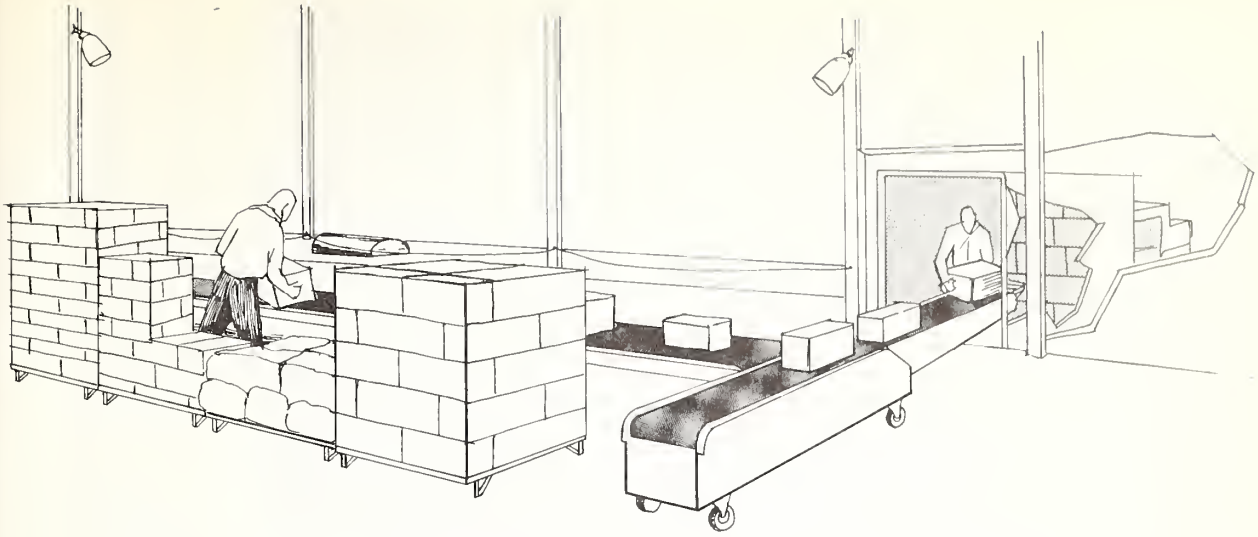

Figure 6.--Transcriber and belt-conveyor installation used with a 2-man selection and loading crew, method B.

The company selected for study to represent method B services affiliated and independent retailers, as well as hotels and restaurants, with a minimum of two deliveries weekly with produce. Warehouse shipments totaled $3 million annually. Orders ranged from one to 300 packages in size, and averaged slightly more than 14 packages per order during the period of the study.

Equipment Requirements

This method uses these powered-belt conveyors: Four 15-foot lengths expandable to 25 feet, and four 32-foot lengths. The method also requires one low-lift electric platform

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Figure 7.--A loader pulling the transcriber cord and listening for items to be selected, method B.

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Figure 8.--A loader removing produce packages from the conveyor and positioning them in a truck, method B.

truck for each man assigned to the assembly operation, as well as dead skids, a battery charger for each platform truck, one dictaphone, four transcribers, and eight speakers and controls. The number of skids would be determined by business volume. More detailed specifications for equipment can be found in appendix tables 24 and 26.

Crew Size

The crew is composed of 10 full-time men and one part-time man. The entire crew begins the work shift by assembling merchandise from storage. The nature of the operation is such that there is no time lost due to crew interference. When each of the four loading stations has merchandise assembled for one truckload, eight crew members cease assembling, pair off into four loading teams of two men each, and commence the loading operation. Two members of the original 10-man crew continue to assemble merchandise for ensuing truckloads. The part-time man (a produce clerk in the office) uses the dictaphone to record customer orders on the plastic belt by assigned truckloads.

Merchandise is shipped 6 days a week by one shift.

MOTORIZED-BELT CONVEYOR AND CHECKER, METHOD C

The motorized-belt conveyor and checker method of assembly and loading is the other method evaluated in this report that is used by service fruit and vegetable wholesalers.

Description

It is composed of two basic operations also. In one operation, merchandise is assembled from storage and is transported to an assembly area on the dock adjacent to a belt conveyor. In the other operation a checker calls items to be placed on the conveyor, crewmen select and place packages on the conveyor, and a 2-man crew loads the truck. Figure 9 shows the conveyor positioned for truckloading and the stations of the crew. Only one truck is loaded at a time.

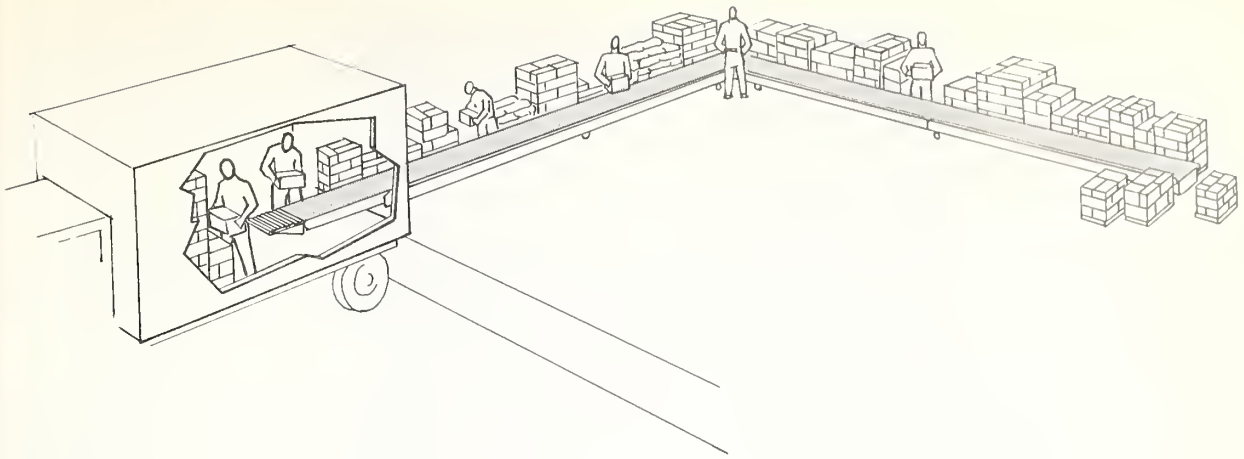

Figure 9.--A diagram of the belt conveyor arrangement with a 6-man order selection and loading crew, method C.

All items in the warehouse are stored on pallets, with 5- and 10-pound bags of potatoes in pallet boxes. Movement of commodities from storage to the assembly area is determined somewhat by conditions required to maintain high quality in produce. For example, some commodities need low-temperature, high-humidity storage. When this type of produce was on order in the warehouse representing method C, only the exact number of packages was brought from storage for a particular load. This was accomplished with a truck recap combined with semilive skids and jacks. Items which did not require special conditioning were brought to the assembly area in palletload quantities by forklift truck.

Another factor controlling the method used to move the product from storage to assembly areas is the sales volume of the commodity. High-volume produce items are brought to the assembly area on pallets without regard to order requirements. Low-volume items are selected from storage areas in exact quantities to fill a truckload, and are transported from storage on skids and are left on those skids in the assembly area until called for by a checker.

Eighty-two percent by weight of the fresh fruits and vegetables shipped, based on data gathered in the study, is brought to the assembly area in palletloads, by a forklift truck, without a recap (appendix table 13). This assembly operation begins when the forklift truck operator starts to stack the assembly area with palletloads of produce. Appendix table 14 gives labor required per ton. It includes driving the forklift truck to a storage point, picking up a palletload, transporting it to the order assembly area, setting down and positioning the loaded pallet alongside the belt conveyor. The forklift truck resupplies the order assembly area during the time the trucks are being loaded, and removes empty pallets. Figure 10 shows the forklift truck operator placing a palletload of potatoes near the conveyor. For comparative purposes an average travel distance of 100 feet is assumed.[7] When all the trucks are loaded, containers of produce remaining in the assembly area are placed on pallets and transported by the forklift truck to the storage area. This part of the operation ends when the last unused containers have been returned to storage.

Eighteen percent of the tonnage brought to the assembly area was placed on semilive skids during the study (appendix table 13). Assembling these items begins when the assemblyman receives a copy of the recap. It includes locating a jack and a semilive skid, transporting the skid to the first storage area, locating items indicated on the recap, placing the packages on the skid, and locating as many additional items in other storage places as the recap calls for until the skid is loaded, or until all the items are obtained. It also includes transporting the loaded skid to the order assembly area and depositing it

[7] See footnote 5.

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Figure 10.--A forklift truck operator assembling a palletload without using a recap sheet, method C.

near the conveyor belt and the order assembly and loading crew. Labor required per ton for this part of the assembly operation is also shown in appendix table 14. The operation ends when all the items on the recap have been selected from storage and transported to the order assembly area. Figure 11 shows assembly with a semilive skid.

Truckloading is the selection of packages by belt loaders from merchandise in the assembly area, when items are called by the checker, and placing packages on the belt. Loaders in the truck remove packages and stack them. The operation begins when the checker calls the first invoice item and belt loaders place packages on the conveyor. To have all the assembled merchandise adjacent to the conveyor, the conveyor needs to be

BN-21946

Figure 11.--An assemblyman performing truck recap assembly using a jack and semilive skid, method C.

about 100 feet long. The portion of the conveyor at right angles to the truck dock is equipped with an Expandoveyor with electrical controls, which is used to move the conveyor into the truck at the start of loading so that it is within 5 feet of the front of the truck body. As the truck is loaded, the conveyor is moved back approximately 3 feet at a time to clear the face of the load (fig. 9). The operation ends when the last package has been stacked in the truck. Labor required per ton to select and load is shown in appendix table 21.

At the end of truckloading, warehouse equipment is placed in a predetermined location, floors are swept, and trash is disposed of. These activities are included in time requirements for setup and cleanup operations shown in appendix table 22.

The company representing method C services affiliated and independent retail stores, as well as hotels and restaurants, with a minimum of two deliveries weekly of produce and frozen foods. Produce warehouse shipments totaled $2.5 million annually. Orders ranged from 1 to 173 packages in size, and averaged slightly less than 18 packages per order during the study.

Equipment Requirements

This method requires these powered-belt conveyors: One 26-foot length expandable to 43 feet, one 90-degree curved section, one 32-foot length, and one 20-foot length. It also requires two jacks, two semilive skids, a counterbalanced forklift truck, plus an extra battery and a charger, and a public address system consisting of a microphone, two speakers, and controls. Each skid holds an average of 20 packages. The conveyors are used to load out. The forklift truck and jacks with skids are used for assembly. The microphone is used by the checker. More detailed specifications for equipment are in appendix tables 25 and 26.

Crew Size

The crew is composed of nine men. Six crew members select merchandise and load as follows: The checker calls out items on order, three men select and place packages on the motorized belt, and two men load trucks. Three men make up the assembly crew: One forklift operator moves palletloads of merchandise, and two men pull semilive skids through the storage area. It is normal procedure for one assembler to work with a semilive skid in the wet box, and for the other assembler to select in the dry box.

Merchandise is assembled for shipment 6 nights per week by one shift, beginning at 7:30 p.m.

COST COMPARISONS WITH THREE METHODS OF ASSEMBLING MERCHANDISE AND LOADING DELIVERY TRUCKS

Costs for warehouse labor and equipment with the three methods are presented in this section in table and graph form. Standards from time-study data and from previous marketing research[8] are used to establish labor requirements per ton and productivity in tons per man-hour when assembling and loading merchandise in order sizes of 5 to 300 packages. Each package is assumed to weigh 40 pounds. Tables 1, 2, and 3 show productive man-minutes of labor required to perform the functions of methods A, B, and C, as well as crew balance delay time, and elapsed time. The tables in this report use the term "crew balance delay" for job-regulated wait time.

[8] See footnote 5.

Table 1.--Labor required and productivity for loading out 1 ton of various sizes of produce orders with method A (slot system)

Order size	Setup and cleanup[1]	Forklift letdown			Select			
		Productive time[2]	Crew balance delay	Elapsed time[3]	Crew size	Productive time[4]	Crew balance delay	Elapsed time
Packages	Man-min.	Man-min.	Man-min.	Min.	No.	Man-min.	Man-min.	min.
5	1.38	2.92	14.47	18.45	3	55.36	--	18.45
10	1.38	2.92	7.82	11.80	3	32.58	2.82	11.80
20	1.38	2.92	3.37	7.35	3	22.04	--	7.35
40	1.38	2.92	1.45	5.43	3	16.28	--	5.43
60	1.38	2.92	1.08	5.06	3	15.17	--	5.06
80	1.38	2.92	.76	4.74	3	14.22	--	4.74
100	1.38	2.92	.67	4.65	3	13.96	--	4.65
200	1.38	2.92	.35	4.33	3	12.98	--	4.33
300	1.38	2.92	.27	4.25	3	12.76	--	4.25

Order size	Load				Total time			Productivity
	Crew size	Productive time[5]	Crew balance delay	Elapsed time	Productive time	Crew balance delay	Total	Tons per manhour
Packages	No.	Man-min.	Man-min.	Min.	Man-min.	Man-min.	Man-min.	No.
5	1	17.00	1.45	18.45	76.66	15.92	92.58	0.65
10	1	11.80	--	11.80	48.68	10.64	59.32	1.01
20	2	9.40	5.30	7.35	35.74	8.67	44.41	1.35
40	2	9.01	1.84	5.43	29.59	3.29	32.88	1.82
60	2	8.88	1.24	5.06	28.35	2.32	30.67	1.96
80	2	8.74	.74	4.74	27.26	1.50	28.76	2.09
100	2	8.65	.64	4.65	26.91	1.31	28.22	2.13
200	2	8.41	.24	4.33	25.69	.59	26.28	2.28
300	2	8.19	.30	4.25	25.25	.57	25.82	2.32

[1] Source: Appendix table 22.

[2] Source: Appendix tables 10 and 11. Equal productive time charged to each order size because letdowns are based on total shipments, not individual orders.

[3] Includes 1.06 man-minutes for receiving one-fourth ton of merchandise for each ton shipped. Appendix table 12 shows a standard time of 4.24 man-minutes per ton for forklift storage. With 25 percent of the merchandise received during shipping hours, 1.06 man-minutes is charged to forklift letdown.

[4] Source: Appendix tables 15 and 16.

[5] Source: Appendix tables 17, 18, and 19.

Table 2.--Labor required and productivity for loading out 1 ton of various sizes of produce orders with method B (conveyor and transcriber system)

Order size	Setup and cleanup[1]	Assemble				Select and load				Total time			Productivity
		Crew size	Productive time[2]	Crew balance delay	Elapsed time	Crew size	Productive time[3]	Crew balance delay	Elapsed time	Productive time	Crew balance delay	Total	Tons per man-hour
Packages	Man-min.	No.	Man-min.	Man-min.	Min.	No.	Man-min.	Man-min.	Min.	Man-min.	Man-min.	Man-min.	No.
5	2.07	1	11.40	0.12	11.52	2	23.04	--	11.52	36.51	0.12	36.63	1.64
10	2.07	1	11.40	--	11.40	2	18.18	4.62	11.40	31.65	4.62	36.27	1.65
20	2.07	2	11.40	4.30	7.85	2	15.70	--	7.85	29.17	4.30	33.47	1.79
40	2.07	2	11.40	3.08	7.24	2	14.47	--	7.24	27.94	3.08	31.02	1.93
60	2.07	2	11.40	2.68	7.04	2	14.08	--	7.04	27.55	2.68	30.23	1.98
80	2.07	2	11.40	2.48	6.94	2	13.87	--	6.94	27.34	2.48	29.82	2.01
100	2.07	2	11.40	2.36	6.88	2	13.75	--	6.88	27.22	2.36	29.58	2.03
200	2.07	2	11.40	2.10	6.75	2	13.50	--	6.75	26.97	2.10	29.07	2.06
300	2.07	2	11.40	2.02	6.71	2	13.42	--	6.71	26.89	2.02	28.91	2.08

[1] Source: Appendix table 22.
[2] Source: Appendix table 14.
[3] Source: Appendix table 20.

Table 3.--Labor required and productivity for loading out 1 ton of various sizes of produce orders with method C (conveyor and checker system)

Order size	Setup and cleanup[1]	Assemble						
		Forklift			Semilive skid			
		Productive time[2]	Crew balance delay	Elapsed time	Crew size	Productive time[2]	Crew balance delay	Elapsed time
Packages	Man-min.	Man-min.	Man-min.	Min.	No.	Man-min.	Man-min.	Min.
5	2.76	3.44	2.50	5.94	1	5.94	--	5.94
10	2.76	3.44	1.21	4.65	2	5.94	3.36	4.65
20	2.76	3.44	.62	4.06	2	5.94	2.18	4.06
40	2.76	3.44	.32	3.76	2	5.94	1.58	3.76
60	2.76	3.44	.22	3.66	2	5.94	1.38	3.66
80	2.76	3.44	.17	3.61	2	5.94	1.28	3.61
100	2.76	3.44	.14	3.58	2	5.94	1.22	3.58
200	2.76	3.44	.08	3.52	2	5.94	1.10	3.52
300	2.76	3.44	.06	3.50	2	5.94	1.06	3.50

Order size	Select and load				Total time			Productivity
	Crew size	Productive time[3]	Crew balance delay	Elapsed time	Productive time	Crew balance delay	Total	Tons per man-hour
Packages	No.	Man-min.	Man-min.	Min.	Man-min.	Man-min.	Man-min.	No.
5	6	35.04	0.60	5.94	44.42	3.10	47.52	1.26
10	6	27.90	--	4.65	40.04	4.57	44.61	1.34
20	6	24.34	--	4.06	36.48	2.80	39.28	1.53
40	6	22.55	--	3.76	34.69	1.90	36.59	1.64
60	6	21.95	--	3.66	34.09	1.60	35.69	1.68
80	6	21.65	--	3.61	33.79	1.45	35.24	1.70
100	6	21.48	--	3.58	33.62	1.36	34.98	1.72
200	6	21.12	--	3.52	33.26	1.18	34.44	1.74
300	6	21.00	--	3.50	33.14	1.12	34.26	1.75

[1] Source: Appendix table 22.
[2] Source: Appendix table 14.
[3] Source: Appendix table 21.

Table 4 shows these requirements converted to dollar costs per ton. Rates of pay for workers include the base hourly wage plus fringe benefits, including such items as social security, workmen's compensation, paid vacations, and unemployment compensation. Higher rates of pay for the checker and forklift truck operator existed in the warehouses studied.

Costs shown in table 5 assume each unit of equipment is used for assembly and loading operations 2,000 hours annually. Some of the equipment--forklift trucks and low-lift platform trucks--is used for both receiving and loading out, and charges are based on 4,000 hours' annual use. Table 6 costs assume use of equipment for assembly and loading

Table 4.--Cost comparison for labor requirements per ton with 3 methods of assembling, selecting, and loading fruits and vegetables, by order size[1]

Order size (packages)	Method A (slot system)					Method B (conveyor and transcriber)				Method C (conveyor and checker system)				
	Setup and cleanup	Forklift letdown	Select orders	Load	Total	Setup and cleanup	Assemble[2]	Select and load	Total	Setup and cleanup	Assemble		Select and load	Total
											Forklift	Skids		
5	$0.052	$0.725	$2.076	$0.692	$3.545	$0.078	$0.432	$0.864	$1.374	$0.104	$0.248	$0.223	$1.337	$1.912
10	.052	.448	1.328	.443	2.271	.078	.428	.855	1.361	.104	.194	.349	1.046	1.693
20	.052	.262	.827	.551	1.692	.078	.589	.589	1.256	.104	.169	.305	.913	1.491
40	.052	.182	.611	.407	1.252	.078	.543	.543	1.164	.104	.157	.282	.846	1.389
60	.052	.167	.569	.380	1.168	.078	.528	.528	1.134	.104	.153	.275	.823	1.355
80	.052	.153	.533	.356	1.094	.078	.521	.520	1.119	.104	.150	.271	.812	1.337
100	.052	.150	.524	.348	1.074	.078	.516	.516	1.110	.104	.149	.269	.806	1.328
200	.052	.136	.487	.324	.999	.078	.506	.506	1.090	.104	.147	.264	.792	1.307
300	.052	.133	.479	.318	.982	.078	.503	.503	1.084	.104	.146	.263	.788	1.301

[1] Based on a wage rate of $2.25 per hour for setup and cleanup, merchandise assemblers (except forklift truck operator), conveyor belt and truck loaders, and $2.50 per hour for checker and forklift operator.
[2] The low-lift platform truck with a dead skid is used for all assembly work.

Table 5.--Per-ton cost for equipment used for loading out 8 hours daily with three methods of assembling, selecting, and loading fruits and vegetables, by order size

Order size (packages)	Method A (Slot system)				Method B (Conveyor and transcriber system)				Method C (Conveyor and checker system)				
	Fork-lift[1]	Tow-tractor[2]	Selector trucks[3]	Total	Electric low-lift platform truck[1 4]	Dead-skids	Belt con-veyor[5]	Total	Fork-lift[1]	Pallets[6]	Jack & semilive skid[7]	Belt con-veyor[8]	Total
5	$0.189	$0.291	$0.137	$0.617	$0.186	$0.033	$0.192	$0.411	$0.093	$0.020	$0.034	$0.106	$0.253
10	.116	.186	.044	.346	.184	.033	.190	.407	.073	.020	.034	.083	.210
20	.068	.116	.016	.200	.127	.033	.131	.291	.063	.020	.034	.073	.190
40	.047	.086	.012	.145	.117	.033	.120	.270	.059	.020	.034	.067	.180
60	.043	.080	.011	.134	.114	.033	.117	.264	.057	.020	.034	.065	.176
80	.040	.075	.011	.126	.112	.033	.115	.260	.056	.020	.034	.065	.175
100	.039	.073	.010	.122	.111	.033	.114	.258	.056	.020	.034	.064	.174
200	.035	.068	.010	.113	.109	.033	.112	.254	.055	.020	.034	.063	.172
300	.035	.067	.009	.111	.108	.033	.112	.253	.055	.020	.034	.063	.172

[1] Forklift trucks and electric low-lift platform trucks are used for receiving as well as loading out with costs based on 4,000 hours annual use. Other equipment is charged for 2,000 hours annual use for loading out only. Source: tables 1, 2, 3, and appendix tables 23, 24, and 25.

[2] Source: Table 1 and appendix table 23.

[3] Source: Table 1 and appendix table 23. Example: Selector truck cost for a 60-package order is $0.0148 times 3 (trucks) or an hourly cost of $0.0444. Elapsed time for a 60-package order is 5.06 minutes. Multiplying this by two for order selection and loading, is 10.12 minutes, plus 50 percent for idle time (5.06 minutes), equals 15.18 minutes. The cost per 15.18 minutes is $0.0112. The number of trucks on a per-ton basis for various size orders would be 10 with 5-package orders, 5 with 10-package orders, and 3 with orders of 20 or more packages.

[4] Source: Table 2 and appendix table 24. Example: Electric low-lift platform truck cost per hour is $0.2423. Elapsed time for a 20-package order is 7.85 minutes. Multiplying this by 2 for order assembly and loading equals 15.70 minutes, and multiplying 15.70 by 2 (trucks) equals 31.40 minutes. The cost per 31.40 minutes is $0.1268.

[5] Source: Table 2 for elapsed time and appendix table 24. An hourly cost of $0.4988 is used for equipment cost including order assembly, selection, and truckloading. The conveyor remains idle while order assembly takes place. Belt conveyor includes the dictaphone, transcriber, speakers, and controls.

[6] Source: Table 7 and appendix table 26. Per-ton pallet cost ($0.0143) times number of pallets required (140) equals $2.002, which divided by 100 tons shipped per day equals $0.020.

[7] Source: Appendix tables 25 and 26. The computed cost per ton ($0.034) is based on total equipment cost divided by tonnage shipped. See table 26, footnote 7, for details.

[8] Cost is based on elapsed time, table 3, and equipment cost, appendix table 25. Belt conveyor includes the microphone, speakers, and controls.

Table 6.--Per-ton cost for equipment used for loading out 16 hours daily with 3 methods of assembling, selecting, and loading fruits and vegetables, by order size

Order size (packages)	Method A (slot system)				Method B (conveyor and transcriber system)				Method C (conveyor and checker system)				
	Fork-lift[1]	Tow-tractor	Selector trucks	Total	Electric low-lift platform truck[1]	Dead-skids	Belt con-veyor	Total	Fork-lift[1]	Pal-lets[2]	Jack & semilive skid[3]	Belt conveyor	Total
5	$0.138	$0.166	$0.082	$0.386	$0.135	$0.033	$0.121	$0.289	$0.068	$0.020	$0.017	$0.065	$0.170
10	.085	.106	.026	.217	.134	.033	.119	.286	.053	.020	.017	.051	.141
20	.050	.066	.010	.126	.092	.033	.082	.207	.046	.020	.017	.044	.127
40	.035	.049	.007	.091	.085	.033	.076	.194	.043	.020	.017	.041	.121
60	.032	.046	.007	.085	.082	.033	.074	.189	.042	.020	.017	.040	.119
80	.029	.043	.006	.078	.081	.033	.073	.187	.041	.020	.017	.039	.117
100	.028	.042	.006	.076	.081	.033	.072	.186	.041	.020	.017	.039	.117
200	.026	.039	.006	.071	.079	.033	.071	.183	.040	.020	.017	.038	.115
300	.025	.038	.006	.069	.079	.033	.070	.182	.040	.020	.017	.038	.115

[1] Forklift trucks and electric low-lift platform trucks are used for receiving as well as loading out with costs based on 6,000 hours annual use. Other equipment is charged for 4,000 hours annual use. Methods of computing costs are those used in table 5.

[2] Pallet cost per ton remains constant.

[3] See table 26, footnote 7, for details of this cost.

operations 4,000 hours annually, or for a two-shift loading operation. Forklift trucks and low-lift platform trucks are therefore costed at 6,000 hours of use. Each 2,000 hours means full use of equipment on a one-shift basis (50 weeks and 40 hours each week). Unproductive and idle machine time is included in the computations and is shown in the differences between productive and elapsed time, depending on crew size.

Some equipment items--pallets, semilive, and dead skids--are costed on the basis of produce turnover because this is more realistic than hours of use. This assumes one use approximately every $4\frac{1}{2}$ days. With the unit-load principle of receiving, storing, and transporting merchandise in produce warehouses, pallets and skids are used to move large quantities of packages as a single unit. Therefore, pallets and skids are normally in a holding status, and immobile, for long periods of time, possibly for a week or longer. The numbers of selector trucks, pallets, and skids needed to assemble merchandise and load out delivery trucks with each method is shown in table 7. Reserves of equipment are assumed at 40 percent of requirements, and are included in the table to eliminate delay time for order selectors and assemblymen when they are ready for the next order assembly. Equipment costs, therefore, are not inflated by use of units at less-than-full capacity, and equitable bases are provided for comparison purposes.

Costs for labor and equipment with each method, on a per-ton basis, for one and two shifts per day have been combined in the final comparison, tables 8 and 9. These costs are shown graphically in figures 12 and 13.

Table 7.--Selector trucks, skids, and pallets with 3 methods of assembling merchandise and loading out delivery trucks[1]

Function	Method A (slot system): Selector trucks	Method B (conveyor and transcriber system): Dead skids	Method C (conveyor and checker system)	
			Semilive skids	Pallets
	Number	Number	Number	Number
Select orders	6	--	--	--
Assemble merchandise	--	10	6	140
Load delivery trucks	2	--	--	--
Trucks or skids assembled on dock	6	16	4	--
Reserve pieces of equipment[2]	6	10	4	--
Total	20	36	14	140

[1] The forklift truck operator is omitted from crew sizes for these computations.
[2] 40 percent of the number of selector trucks and skids required for selection and assembly, loading, and holding on the dock.

Table 8.--Cost comparison for labor and equipment per ton (8 hours loading out daily) with 3 methods of assembling, selecting, and loading fruits and vegetables, by order size

Order size (packages)	Method A (slot system)			Method B (conveyor and transcriber system)			Method C (conveyor and checker system)		
	Labor	Equipment	Total	Labor	Equipment	Total	Labor	Equipment	Total
5	$3.545	$0.617	$4.162	$1.374	$0.411	$1.785	$1.912	$0.253	$2.165
10	2.271	.346	2.617	1.361	.407	1.768	1.693	.210	1.903
20	1.692	.200	1.892	1.256	.291	1.547	1.491	.190	1.681
40	1.252	.145	1.397	1.164	.270	1.434	1.389	.180	1.569
60	1.168	.134	1.302	1.134	.264	1.398	1.355	.176	1.531
80	1.094	.126	1.220	1.119	.260	1.379	1.337	.175	1.512
100	1.074	.122	1.196	1.110	.258	1.368	1.328	.174	1.502
200	.999	.113	1.112	1.090	.254	1.344	1.307	.172	1.479
300	.982	.111	1.093	1.084	.253	1.337	1.301	.172	1.473

Table 9.--Cost comparison for labor and equipment per ton (16 hours loading out daily) with 3 methods of assembling, selecting, and loading fruits and vegetables, by order size

Order size (packages)	Method A (slot system)			Method B (conveyor and transcriber system)			Method C (conveyor and checker system)		
	Labor	Equipment	Total	Labor	Equipment	Total	Labor	Equipment	Total
5	$3.545	$0.386	$3.931	$1.374	$0.289	$1.663	$1.912	$0.170	$2.082
10	2.271	.217	2.488	1.361	.286	1.647	1.693	.141	1.834
20	1.692	.126	1.818	1.256	.207	1.463	1.491	.127	1.618
40	1.252	.091	1.343	1.164	.194	1.358	1.389	.121	1.510
60	1.168	.085	1.253	1.134	.189	1.323	1.355	.119	1.474
80	1.094	.078	1.172	1.119	.187	1.306	1.337	.117	1.454
100	1.074	.076	1.150	1.110	.186	1.296	1.328	.117	1.445
200	.999	.071	1.070	1.090	.183	1.273	1.307	.115	1.422
300	.982	.069	1.051	1.084	.182	1.266	1.301	.115	1.416

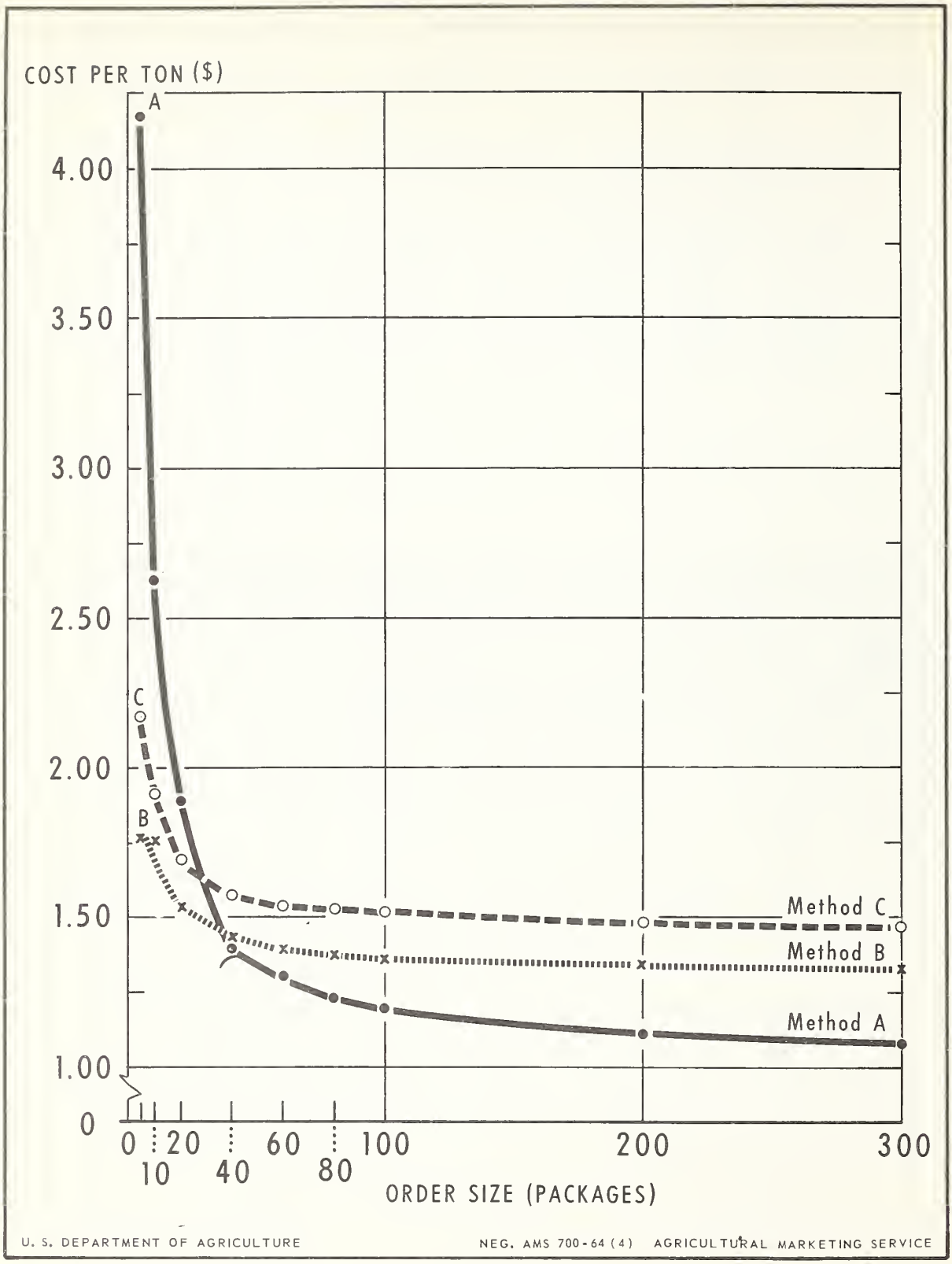

Figure 12.--Costs for loading out one ton of produce, by order size, with three methods (one shift per day).

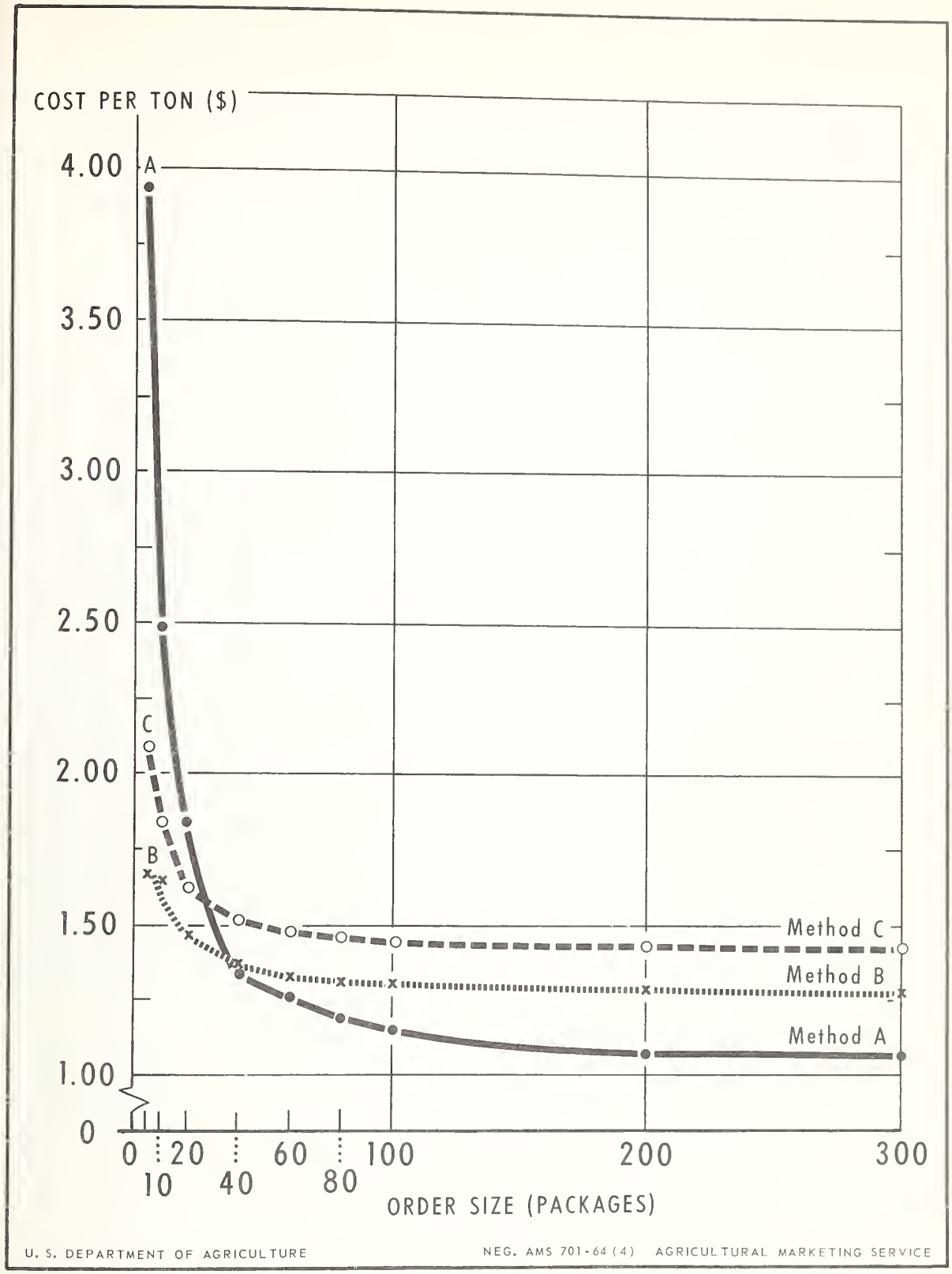

Figure 13.--Costs for loading out one ton of produce, by order size, with three methods (two shifts per day).

THE INFLUENCE OF ORDER SIZE ON SELECTION OF AN ASSEMBLY AND LOADING METHOD

Size of order handled in the warehouse influences labor productivity in loading out.[9] Method A (slot system) is efficient for handling large orders because travel time per package decreases as order size increases. The entire warehouse area must be traveled whether a small or large order is assembled, so travel distance will be distributed among a greater number of packages when large orders are assembled. With method B (conveyor and transcriber system) and method C (conveyor and checker system), the size of individual orders does not influence the travel time or distance in order assembly. Order assembly is on a truck recap basis, (a truck recap sums up the units of each produce item to be loaded on a particular truck) or a group recap basis, (summary of commodities ordered by several truckloads) with methods B and C.

The travel time per package with a 100-package order would be less than travel time per package with two 50-package orders in a warehouse using method A because the total warehouse area must be traveled for each order. In a warehouse using method B or method C, one cycle through the warehouse will be necessary for each recap whether there are one or several orders in the recap.

Figure 14 shows the percentage of packages shipped, by order size groups, in three firms. In firm A, representing method A, about 10 percent of all orders were less than 30 packages in size while in firm B, representing method B, about 50 percent of all orders were in this size category, and in firm C, representing method C, about 41 percent were less than 30 packages in size. Orders of less than 50 packages accounted for 28 percent of all orders in firm A, 62 percent in firm B, and 58 percent in firm C. Thus, the larger size orders (over 50 packages) were concentrated in firm A, 72 percent; and small orders (less than 30 packages) were concentrated in firm B, 50 percent; and firm C, 41 percent.

Order size in the study ranged from 1 to 438 packages, and averaged 66.9 packages in firm A, 14.1 packages in firm B, and 17.9 packages in firm C.

Table 8 shows a cost of $1.892 per ton for labor and equipment used with method A to assemble, select, and load out an order of 20 packages. The cost for method B is $1.547, and for method C is $1.681. For a 40-package order the costs are $1.397 for A, $1.434 for B, and $1.569 for C. These costs, plotted in figure 12, show the break-even point is about 37 packages between methods A and B, and about 27 packages between A and C. Costs for a two-shift operation, plotted in figure 13, place the break-even points between any of the three methods at about the same places.

On the basis of average order size, concentration of orders shipped within order size groupings shown in figure 14, and costs shown in tables 8 and 9, firm A, representing method A, is using the lowest cost method for assembling and loading out produce. The firm representing method B, firm B, is also using the lowest cost method for assembling and loading out. Firm C, representing method C, would have lower costs if it were to use method B.

By averaging sizes of orders shipped, and by studying order size concentrations over a typical period, it will be possible for the management of a firm to select the method of assembly and loading out that costs least. An analysis of this type will be particularly beneficial in planning warehouse renovation, expansion, or new construction. For example, with this information, management of the firm representing method C (average order size, 17.9 packages) may find it advantageous to incorporate method B when the layout of the warehouse is changed. Cost per ton for an order size of 18 packages, shown in table 8 and figure 12, (one-shift loading out) is about $1.57 for method B and about $1.71 for method C--a savings of $0.14 per ton with method B.

[9] Bouma, John C., Methods of Increasing Productivity in Modern Grocery Warehouses. U.S. Dept. Agr. Mktg. Res. Rpt. No. 94, 30 pp. illus. June 1955.

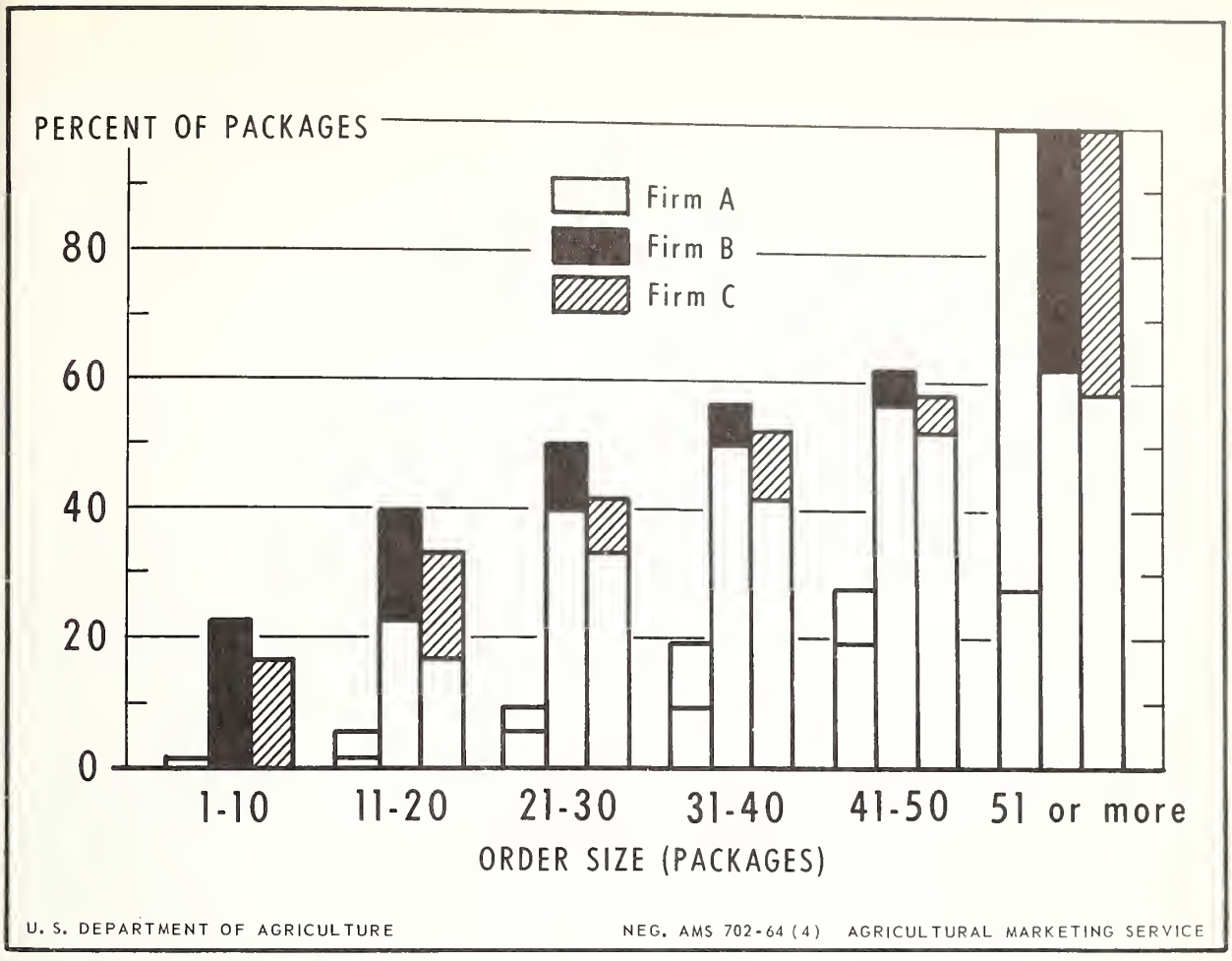

Figure 14.--Cumulative percentage of packages shipped in three firms, by order size groups.

With an average of 100 tons loaded out daily, method B would save $14 a day, or $3,500 a year (250 working days). Cost per ton for an order size of 18 packages, shown in table 9 and figure 13 (two-shift loading out), is about $1.50 for method B and $1.69 for method C, a saving of $0.19 a ton. Assuming an average of 200 tons of produce shipped daily (two-shift operation), use of method B would save $38 per day, or $9,500 per year for firm C.

The foregoing evaluations do not exhaust wholesaling research possibilities. Management has problems with administration, customer affiliation, and with warehousing itself. Examples are: Problems in receiving produce, and in repacking some commodities in quantities smaller than standard field packs. Although those problems are beyond the scope of the research in this report, they would have a bearing on the total efficiency attained by any wholesale produce firm.

APPENDIX

Tables developed from analysis of data and methods and techniques used to develop costs of operations are presented in the appendix. Standard times contained in the tables form the bases for discussions in the text of the report.

Research Methods and Techniques

The first step in establishing research methodology in a firm is orientation of the firm's warehouse personnel about purposes for, and objectives of, the study. An explanation is given the workers of techniques to be used during the research. These techniques include stopwatch timing of workers as they perform their assigned jobs, critical observation of warehousing methods, and questioning of personnel about details of their work. They include also discussions with management and supervisory personnel about factors related to assembling merchandise and loading delivery trucks such as delivery schedules, order sizes, buying methods, and order-taking routines. Pictures are taken of warehouse operations while the study is in progress to: (1) Obtain visual evidence of problem areas for talks with warehouse management; and (2) enable researchers to prepare a more valuable report of findings.

Research personnel, as a second step, inform the warehousemen of the desirability of performing their tasks in a normal manner. Workers are reminded that a research objective is to make warehouse jobs easier. The third step is to encourage employees to make suggestions and criticisms about warehouse methods.

Each employee with the three methods of assembling merchandise and loading delivery trucks was timed. A decimal-minute stopwatch was used to obtain times for each element of work observed. Delays were recorded and identified and their causes were determined. All delays classified as avoidable were removed from the time requirements established for the work. Unavoidable delays, such as waiting time of assemblers for space to place a package on a conveyor are included in total labor requirements for each work component. These unavoidable delays are usually inherent in the loading method.

During the course of recording data in a time study, a trained observer made several judgments of the pace of the worker, and expressed these estimates, using 100 as an index of normal pace. These estimates are called ratings, defined by Barnes as: ". . . that process during which the time study analyst compares the performance (speed or tempo) of the operator under observation with the observer's own concept of normal performance..."[10] Skill is not considered to be a factor in individual performance since it is defined as the ability of the individual to follow a given motion pattern.[11] A recording that is higher than normal, or more than 100, means that an employee's movements are faster than normal. A recording that is below 100, indicates that a worker's pace is slower than the norm. The observed time is multiplied by the assigned rating(s) to obtain the time that would be required to perform the job at a normal pace. The time value obtained by the above multiplication is known as the base time. Studies in different parts of the United States indicate that the speed at which people work varies from one region to another, or from one locality to another. These variations are compensated for as indicated. Data are therefore comparable.

Time values used in this report are standard times. Standard time is equal to the base time plus allowances for fatigue and personal needs. The fatigue allowance is included to provide time for the assigned worker to rest to overcome fatigue resulting from sustained physical effort. The percentage value used for the allowance is directly related to physical difficulty and the working conditions associated with an assigned job.

Fatigue and Personal Allowances

Allowances shown below are applicable to the performance of indicated handling operations in the warehouses of wholesale distributors of fresh fruits and vegetables. A personal allowance of 5 percent has been added in every instance to the fatigue allowance to provide the total allowance figure listed. This allowance is generally accepted as adequate for worker comfort because it provides 24 minutes in an 8-hour work shift.

[10] Barnes, Ralph M. Motion and Time Study. Ed. 4, 655 pp., illus. New York. 1958.
[11] Presgrave, Ralph. The Dynamics of Time Study. Ed. 2, 238 pp. New York. 1945.

Operation of:

	Percent
1. Selector trucks and towtractor (power equipment for order selection), method A	15
2. Manual loading, methods A, B, and C	20
3. Forklift truck (power equipment for assembly and merchandise letdown), methods A and C	10
4. Dead skid and low-lift platform truck (power equipment for merchandise assembly), method B	15
5. Semilive skid and jack (manual equipment for assembly), method C	20
6. Setup and cleanup operations, methods A, B, and C	15

Time standards for assembling merchandise and loading delivery trucks with the three methods are then determined. Before actual collection of data on which to base determinations, however, a number of practice runs are made of each operation to give the workers the feel of being timed, and to let the observers check their recording and watch-reading procedures. Job elements are determined and described. Studies are then made of the assembly and loading operations during the working hours and under the conditions that normally exist in the industry. Equipment types are representative of those used by wholesale produce operators with the three methods.

Element descriptions for order selection, merchandise assembly, and truckloading with the three methods are given below.

Element Descriptions for Order Selection and Truckloading Operations When Method A is Used

Order Selection:

1. Obtain order and check: Begins when man picks up order at desk. Includes grasping, lifting, reading the order; walking to tractor and clipping order on board. Ends when man grasps controls on tractor.

2. Obtain selector truck: Begins when man grasps controls on tractor. Includes looking for, traveling to and hooking up selector truck(s) to tractor, climbing on tractor. Ends when man grasps controls on tractor.

3. Travel from dock to selection line: Begins when man grasps tractor controls. Includes starting tractor and traveling to selection line. Ends when tractor is stopped at first select point.

4. Travel on selection line: Begins when selector releases package on selector truck and includes travel from one selection point to next, starting and stopping tractor. Ends when man stops tractor.

5. Select produce: Begins when man stops tractor. Includes walking to slot, grasping and transporting package. Ends when package is released on selector truck.

6. Check and study invoice: Begins when man releases package on selector truck. Includes checking off item selected, studying invoice. Ends when man walks toward merchandise for selection or grasps tractor controls and starts forward motion.

7. Mark selector truck slate: Begins when man releases package on selector truck. Includes grasping eraser and chalk, erasing board, marking store number on each selector truck. Ends when man releases chalk and eraser in receptacle.

8. Travel to dock: Begins when man grasps tractor controls. Includes starting tractor and traveling to dock. Ends when forward motion of tractor train stops.

9. Drop selector truck: Begins when forward motion of tractor train stops. Includes releasing selector trucks. Ends when man grasps tractor controls.

10. To order desk: Includes travel to order desk.

Repeat elements until order selection for a single order is complete.

Truckloading:

1. Pick up loaded selector truck: Begins when empty selector truck is released or when worker starts toward selector truck. Includes walking to loaded selector truck, grasping and starting to move selector truck. Ends when loaded selector truck clears original position.

2. Transport loaded: Begins when loaded selector truck clears original position. Includes transporting loaded selector truck to delivery truck. Ends when loaded selector truck contacts bridge plate.

3. Enter carrier: Begins when loaded selector truck contacts bridge plate. Includes crossing bridge plate, transporting loaded selector truck to storage point, placing it in proper position, and releasing loaded selector truck. Ends when worker releases grasp on selector truck.

4. Load in truck: Begins when worker releases grasp on selector truck or starts toward load. Includes walking to load, grasping package, lifting and securing package, carrying to stack, positioning and releasing in stack. Ends when last package is released in the stack.

5. Leave carrier: Begins when last package is released in stack or when worker starts toward empty selector truck. Includes walking to empty selector truck, grasping, moving clear of original position, transporting to and crossing bridge plate. Ends when empty selector truck clears bridge plate.

6. Transport empty: Begins when selector truck clears original position. Includes transporting empty selector truck to storage area. Ends when worker starts to position or stop selector truck.

7. Set down empty selector truck: Begins when worker starts to position or stop empty selector truck for set down. Includes positioning and releasing empty selector truck. Ends when transporter releases grasp on selector truck.

Repeat elements until truckloading for a single order is complete.

Element Descriptions for Merchandise Assembly and Truck Loading Operations When a Belt Conveyor and Allied Equipment are Used, Methods B and C

1. Order Assembly: Begins when worker starts toward empty skid. Includes walking to skid, engaging skid with a jack or a low-lift platform truck, grasping controls and starting to move skid, transporting skid to storage area, positioning and releasing skid, walking to stacks, grasping packages, lifting and securing packages, carrying to skid, positioning and releasing packages in load, walking to jack and grasping controls, starting

to move skid, moving skid in storage area, transporting loaded skid to assembly area or loading platform, positioning and releasing loaded skid. Ends when worker releases grasp on controls after disengaging skid from jack or low-lift platform truck.

(a) Assemble produce in unit loads: Begins when forklift truck operator receives instructions on the number of unit (pallet) loads to be assembled or begins when forks clear face of load after set down in order assembly area. Includes transport empty to storage area, pick up loaded pallet, transport loaded, and set down loaded pallet in order assembly area. Ends when forks clear face of load.

(b) Assemble produce by group recap: Begins when worker receives instructions or a recap indicating the number of packages to be assembled or begins when last package is released in order assembly area. Includes walking to empty materials-handling equipment, grasping, and starting to move equipment, transporting equipment to storage area, positioning of equipment, walking to stack, grasping, lifting, securing, carrying, positioning and releasing packages in load on equipment, grasping, starting to move and transporting loaded equipment to order assembly area and off-stacking packages required at each truck load. Ends when worker releases last package in order assembly area.

Repeat elements until assembly is complete.

2. Truckloading:

(a) Listen to recorder: Begins when man releases package on belt. Includes walking to and grasping cord, listening to recording. Ends when cord is released.

(b) Place packages on belt: Begins when checker calls first invoice item or begins when package is released on belt. Includes walking to package location in order assembly area, grasping, lifting, securing, and transporting to, positioning, and releasing packages on belt.

(c) Load package in truck: Begins when loader walks to conveyor or begins when package is released in stack. Includes walking to belt, grasping, lifting, securing, transporting, positioning, placing, and releasing package in stack. Ends when package is released in stack.

(d) Crew balance delay: Begins when productive work of placing packages on belt or loading packages in truck stops. Includes waiting for space on belt to place package, waiting for another worker to place his package on belt, waiting for package to reach end of belt for loading in truck, or waiting for worker to complete placing package in stack. Ends when productive work of placing or loading packages is resumed.

(e) Extend conveyor: Move conveyor into or out of truck--adjust extension as loading proceeds.

(f) End truckloading when last package is placed in the load.

Repeat elements until truckloading is complete.

Tables of Labor Requirements

The next step is the development of labor requirements for the three methods, which are shown for the different operations in tables 10 through 22.

Time required per pallet of produce for the forklift truck operator to stock slots for order selection with method A is reported in table 10.

Table 10.--Time required, per pallet of produce, for forklift-truck operator to stock slots for order selection, method A

Work element	Distance	Labor required
	Feet	Man-minutes
Transport empty	[1] 260	0.55
Pick up empty pallet first tier		0.22
Transport loaded	10	0.08
Set down empty pallet		0.20
Transport empty	10	0.08
Pick up load[2]		0.27
Set down load first tier		0.25
Transport empty	10	0.08
Pick up empty pallet		0.11
Transport loaded	260	0.55
Total base time		2.39
Standard time		[3] 2.63

[1] Assumed average travel distance within the selection area. Actual distance varied from 216 feet to 305 feet.
[2] Loaded pallets in second and third tiers. Palletload weight is 1,200 pounds.
[3] Fatigue and personal allowance of 10 percent added.

The time required for forklift truck letdowns per ton of produce shipped is shown in table 11.

Table 11.--Time required, per ton of produce shipped, for forklift-truck operator to make pallet letdowns, method A

Item	Unit	Number
Volume loaded out daily	Ton	100
Number of palletload equivalents shipped	Palletload	[1] 167
Number of pallets let down to selection slots	Palletload	[2] 111
Standard time required for lowering one pallet	Man-minutes	2.63
Standard time required for lowering 1.11 pallets per ton shipped	Man-minutes	[3] 2.92

[1] Based on 1,200 pounds per pallet.
[2] Produce is normally stored 3-pallets high in racks with method A. For every 3 palletloads shipped 2 pallets must be lowered for selection, thus 111 pallets must be lowered for every 100 tons shipped.
[3] Since there are 1.67 pallets per ton, 1.11 pallets must be lowered as shown in footnote 2.

Table 12 shows the labor time required by the forklift truck operator to receive a ton of fruits and vegetables. Included are times to pick up a palletload on the dock, and to put it away in a storage rack.

Table 12.--Time required, per ton of produce received, for forklift-truck operator to place merchandise in storage

Work element	Unit	Number	Labor required
			Man-minutes
Pick up load[1]			0.15
Transport loaded	(feet)	[2] 370	.93
Position palletload in rack[3]			.35
Lower forklift			.10
Transport empty	(feet)	370	.78
Total base time			2.31
Standard time per pallet			[4] 2.54
Volume loaded out daily	(ton)	100	
Number of palletload equivalents shipped	(palletload)	167	
Standard time per ton			[5] 4.24

[1] Palletload weight is 1,200 pounds.
[2] Average one-way transport distance of 110 feet from dock to start of selection area, and 260 feet in the selection area.
[3] Assuming an average time for positioning a palletload.
[4] Fatigue and personal allowance of 10 percent added.
[5] There are 1.67 pallets per ton.

Studies in the warehouse using method C showed an average of 82 percent of produce in storage assembled in unit loads on pallets, and the remainder assembled on semilive skids in individual package lots from a recap. Table 13 shows the daily breakdown for assembly by forklift truck, and in package lots by semilive skid and jack with a warehouse doing an annual volume of 1,000 carloads. A breakdown is not presented for method B because the low-lift pallet jack with a dead skid is used exclusively for assembly, and there is no combination of different types of equipment.

Table 13.--Number of palletloads and skidloads brought daily from storage to the assembly area by forklift truck, and by semilive skid and jack, method C, assuming an annual business volume of 1,000 carlots ($2 million)

Item	Unit	Number
Maximum volume loaded out	Ton	100
Quantity in storage with 4 1/2-day turnover	Palletload	[1] 750
Quantity brought to assembly area by forklift	Palletload	[2] 137
Quantity brought to assembly area by semilive skid and jack[3]	Skidload	42

[1] Assuming a weight of 1,200 pounds per palletload.
[2] 82 percent, or 164,000 pounds, moved for selection daily divided by 1,200 pounds equals 137 palletloads.
[3] 18 percent, or 36,000 pounds, moved on semilive skids daily divided by 850 pounds (average skidload) equals 42 skids.

The labor requirement for B and C, using the equipment described for each method, to assemble one ton of produce is shown in table 14.

Table 14.--Labor required to assemble 1 ton of fresh fruits and vegetables, using methods B or C and their materials-handling equipment[1]

Method	Recap type	Base time	Allowances[2]	Standard time
		Man-min.	Man-min.	Man-min.
B Dead skid and electric low-lift platform truck	Group off-stacked by truck recap	9.91	1.49	11.40
C Pallet and forklift truck; semilive skid and jack[3]	82 percent, no recap; 18 percent truck recap.	8.08	1.30	9.38

[1] Assuming an average travel distance of 100 feet from storage to assembly area.
[2] See listings on p. 29 , appendix.
[3] A forklift truck and a 48-inch by 40-inch pallet were used to move 82 percent of the tonnage; standard time was 4.20 man-minutes per ton. Semilive skid and jack were used for 18 percent of the tonnage; standard time was 33 man-minutes per ton.

Tables 15 and 16 present labor requirements for order selection with method A.

The data in table 16 are derived from table 15. For example, for an order size of 100 packages, items (1), (2), (3), (4), (5), and (6) in table 15 are used as follows:

Item	Time Man-minutes	Time for 100 package order Man-minutes
(1)	2.052 (one order)	2.052
(2)	.738 X 1 (cycle with 1 selector truck)	.738
(3)	1.362 X 2 (cycles with 2 selector trucks)	2.724
(4)	.196 X 100 (packages)	19.600
(5)	1.243 X 1 (miscellaneous elements)	1.243
(6)	.523 X 3 (cycles)	1.569
Total		27.926

The total time is then divided by 2 (4,000 pounds is the weight of this order) to obtain the standard time per ton to select a 100-package order, 13.963 man-minutes.

Labor requirements, using method A, to load trucks are given in tables 17 through 19.

Labor requirements to select packages in the assembly area and load trucks, using methods B and C, are shown in tables 20 and 21. Selection of packages and loading of trucks are part of the same operation, and are performed concurrently. The order assemblers place packages on the conveyor belt, while the truck loaders remove packages and load them in the truck. Therefore, labor required is presented in one table for each method.

Table 15.--Labor required for order selection with method A, using a towtractor and selector trucks

Work element	Basis	Base Time	Allowances[1]	Standard time	
		Man-min.	Man-min.	Man-min.	
Obtain and read order.....	Order	0.710	0.107	0.817	
Travel[2].....	Distance	1.074	.161	1.235	
(1) Total					2.052
Obtain selector truck.....	Truck	.346	.052	.398	
Drop selector truck.....	Truck	.081	.012	.093	
Mark selector truck.....	Truck	.215	.032	.247	
(2) Total					.738
Obtain 2 selector trucks.....	Train	.692	.104	.796	
Drop 2 selector trucks.....	Train	.162	.024	.186	
Mark 2 selector trucks.....	Train	.330	.050	.380	
(3) Total					1.362
Select merchandise.....	Package	.108	.016	.124	
Start and stop towtractor.....	Package	.031	.005	.036	
Check off selections and study invoice.....	Package	.031	.005	.036	
(4) Total					0.196
(5) Miscellaneous, total[3].....	Order	1.081	.162		1.243
(6) Cycle time, total[4].....	Cycle	.455	.068		.523

[1] A fatigue and personal allowance of 15 percent is provided for each element.

[2] Travel of 520 feet, at 484 feet per minute. This travel is within the order selection area.

[3] Includes such miscellaneous elements as calling for letdown, waiting for forklift letdown, set aside broken cases, correcting selection errors, checking on commodity description, hunting for merchandise, rearranging merchandise on selector truck, and waiting--other selector in way.

[4] Travel of 220 feet, at 484 feet per minute. This is the average round-trip distance between the dock and the start of the selection area, and the end of selection line and the dock. Cycle time may be for either 1 or 2 selector trucks in tow.

Table 16.--Labor required per ton to select various size orders using 1 man, a towtractor and selector trucks, method A

Order size	Selector trucks per order	Cycles per order	Weight per order	Standard time per order[1]	Standard time per ton
Packages	Number	Number	Tons	Man-minutes	Man-minutes
5	1	1	0.1	5.536	55.360
10	1	1	0.2	6.516	32.580
20	1	1	0.4	8.476	22.038
40	2	1	0.8	13.020	16.275
60	3	2	1.2	18.201	15.168
80	4	2	1.6	22.745	14.216
100	5	3	2.0	27.926	13.963
200	10	5	4.0	51.920	12.980
300	15	8	6.0	76.551	12.758

[1] Fatigue and personal allowances of 15 percent included in standard time.

Table 17.--Labor required, per occurrence, to transport and position a selector truck in carrier for truck loading, method A

Work element	Base time	Allowances[1]	Standard time
	Man-min.	Man-min.	Man-min.
Obtain loaded selector truck.....	0.04	0.01	0.05
Transport loaded (10 feet).	.06	.01	.07
Enter carrier (20 feet)....	.18	.04	.22
Release loaded selector truck.....	.03	.01	.04
Move empty selector truck..	.03	.01	.04
Leave carrier (20 feet)....	.16	.03	.19
Transport empty (10 feet)..	.06	.01	.07
Release empty.....	.03	.01	.04
Total.....	.59	.13	.72

[1] Fatigue and personal allowances of 20 percent.

Table 18.--Labor required for 1 man to stack packages of produce from a selector truck in carrier, method A[1]

Order size	Base time	Allowances[2]	Standard time
Packages	Man-minutes	Man-minutes	Man-minutes
5	0.82	0.16	0.98
10	1.37	0.27	1.64
20	2.53	0.51	3.04
40	4.81	0.96	5.77
60	7.08	1.42	8.50
80	9.25	1.85	11.10
100	11.42	2.28	13.70
200	22.04	4.41	26.45
300	31.95	6.39	38.34

[1] Operation begins when worker releases grasp on selector truck or starts toward load. Includes walking to load, grasping package, lifting and securing package, carrying to stack, positioning and releasing in stack. Ends when last package is released in stack.
[2] Fatigue and personal allowances of 20 percent.

Table 19.--Labor required per ton for 1 man, using a selector truck, to load delivery trucks, method A

Order Size	Selector trucks per order	Cycles per order	Weight per order[1]	Transport & position selector truck[2]	Load packages[2]	Standard time per order[2]	Standard time per ton[2]
Packages	Number	Number	Tons	Man-min.	Man-min.	Man-min.	Man-min.
5	1	1	0.1	0.72	0.98	1.70	17.00
10	1	1	0.2	0.72	1.64	2.36	11.80
20	1	1	0.4	0.72	3.04	3.76	9.40
40	2	2	0.8	1.44	5.77	7.21	9.01
60	3	3	1.2	2.16	8.50	10.66	8.88
80	4	4	1.6	2.88	11.10	13.98	8.74
100	5	5	2.0	3.60	13.70	17.30	8.65
200	10	10	4.0	7.20	26.45	33.65	8.41
300	15	15	6.0	10.80	38.34	49.14	8.19

[1] Average weight per package is 40 pounds.
[2] Includes a fatigue and personal allowance of 20 percent.

Table 20.--Labor required for various order sizes with a 2-man crew, with method B, using a transcriber and a 57-foot belt conveyor to select orders and load trucks

Order size	Weight per order[1]	Base time per order	Base time per ton	Allowances[2]	Standard time per ton	
Packages	Tons	Man-min.	Man-min.	Man-min.	Man-min.	Man-hr.
5	0.1	1.92	19.20	3.84	23.04	0.384
10	0.2	3.03	15.15	3.03	18.18	.303
20	0.4	5.23	13.08	2.62	15.70	.262
40	0.8	9.65	12.06	2.41	14.47	.241
60	1.2	14.07	11.73	2.35	14.08	.235
80	1.6	18.49	11.56	2.31	13.87	.231
100	2.0	22.91	11.46	2.29	13.75	.229
200	4.0	45.00	11.25	2.25	13.50	.225
300	6.0	67.09	11.18	2.24	13.42	.224

[1] Based on average package weight of 40 pounds.
[2] Fatigue and personal allowance of 20 percent.

Table 21.--Labor required for various size orders with a 6-man crew, using method C, and a 95-foot belt conveyor to select orders and load trucks

Order size	Weight per order[1]	Base time per order	Base time per ton	Allowances[2]	Standard time per ton	
Packages	Tons	Man-min.	Man-min.	Man-min.	Man-min.	Man-hr.
5	0.1	2.92	29.20	5.84	35.04	0.584
10	0.2	4.65	23.25	4.65	27.90	.465
20	0.4	8.11	20.28	4.06	24.34	.406
40	0.8	15.03	18.79	3.76	22.55	.376
60	1.2	21.95	18.29	3.66	21.95	.366
80	1.6	28.87	18.04	3.61	21.65	.361
100	2.0	35.79	17.90	3.58	21.48	.358
200	4.0	70.39	17.60	3.52	21.12	.352
300	6.0	104.99	17.50	3.50	21.00	.350

[1] Based on average package weight of 40 pounds.
[2] Fatigue and personal allowance of 20 percent.

Table 22 shows labor for setup and cleanup, per ton of fresh fruits and vegetables assembled and loaded, with the three methods. This labor requirement applies with use of equipment described in the report.

Tables of Equipment Requirements, and Estimated Cost of Ownership and Operation, Per Machine

The last step in the evaluation determines cost of equipment used with the three methods. Cost is given per year and per hour of use.

Six combinations of equipment, used under commercial operating conditions, were observed and studied. These are: Pallets and extendable-fork lift trucks; selector trucks and towtractors; dead skids and low-lift platform trucks; semilive skids and jacks; pallets and counter-balanced forklift truck; and powered belt conveyors of various lengths. Some of the equipment is used with more than one method of assembly and loading evaluated in the report. Voice transmitting equipment observed during the study include a transcriber, speakers, and controls used by the belt loader with method B; and a microphone, speakers, and controls used by the checker with method C.

Specifications for this equipment and estimated cost of ownership and operation, per unit, are in tables 23 through 25. General descriptive terms for an individual machine are given in the first column of each table headed "Type of Equipment."

Initial cost of equipment, column 2 of tables 23 through 25 is based on manufacturers' prices, f.o.b., their plants, through 1963.

The expected life of equipment (column 3), reflects requirements of tax policies of the Federal Government as well as depreciation suggested by manufacturers. Battery-powered forklift trucks and low-lift platform trucks which are used in additional warehousing activities are depreciated at the same rate (column 5), but are charged with the cost of a second battery.

An interest rate of 5 percent (column 6) is assumed adequate to cover the cost of money borrowed, or company assets invested, for equipment.

Table 22.--Labor requirements for setup and cleanup, per ton assembled and loaded, all methods.

Work element	Method A (slot system)			Method B (conveyor and transcriber system)			Method C (conveyor and checker system)		
	Base time (man-min.)	Fatigue and personal allowances (man-min.)[1]	Standard time (man-min.)	Base time (man-min.)	Fatigue and personal allowances (man-min.)[1]	Standard time (man-min.)	Base time (man-min.)	Fatigue and personal allowances (man-min.)[1]	Standard time (man-min.)
Assembly operation									
Cleanup--Begins when truck loading operations end. It includes placing materials-handling equipment in a central location, sweeping order-assembly area and disposing of garbage and trash. Ends when order-assembly area is ready for subsequent assembly operations.....	1.20	0.18	1.38	1.20	0.18	1.38	1.80	0.27	2.07
Truckloading operation[2]									
Setup and cleanup--Begins when truck has been moved into position. Includes moving conveyor into the truck; starting conveyor belt, moving conveyor out of truck; and stopping conveyor belt. Ends when conveyor belt stops.....	--	--	--	0.60	0.09	0.69	0.60	0.09	0.69
Total.....	1.20	0.18	1.38	1.80	0.27	2.07	2.40	0.36	2.76

[1] Fatigue and personal allowance of 15 percent.
[2] Time is also included for transporting unused packages of produce to proper storage areas. An average truckload of 6 tons is assumed to convert time required per truck to a per-ton basis.

Table 23.--Estimated cost of ownership and operation, per machine, of warehouse equipment used in shipping produce with method A.

Type of equipment	Initial cost[1]	Expected useful life[2]	Assumed use per year	Ownership cost per year				Operation cost per year			Total ownership and operation cost	
				Depreciation	Interest at 5 percent	Insurance and taxes at 4 percent	Total	Electricity[3]	Maintenance[4]	Total	Per year	Per hour
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Towtractor, standup rider-type (550-pound draw bar pull, electric)	Dollars	Number	Hours	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Machine	1,415.00	8	--	176.88	--	--	--	--	--	--	--	--
Battery, 6.22-kw-hr. capacity	585.10	5	--	117.02	--	--	--	--	--	--	--	--
Charger	309.00	8	--	38.63	--	--	--	--	--	--	--	--
Total	2,309.10	-	2,000	332.53	115.46	92.36	540.35	[5] 55.98	34.64	90.62	630.97	.3155
	2,309.10	-	4,000	332.53	115.46	92.36	540.35	111.96	69.28	181.24	721.59	.1804
(2) Four-wheel selector truck (3000-pound capacity, rubber-tired wheels, automatic coupler, platform size 36 by 60 inches).	[6] 123.36	10	2,000	12.34	6.17	4.93	23.44	--	6.17	6.17	29.61	.0148
	123.36	10	4,000	12.34	6.17	4.93	23.44	--	12.34	12.34	35.78	.0089
(3) Extendable-forklift truck (3,000-pound capacity)												
Machine	6,600.00	8	--	825.00	--	--	--	--	--	--	--	--
Battery, 14.06-kwh. capacity.	1,000.00	5	--	200.00	--	--	--	--	--	--	--	--
Charger	500.00	8	--	62.50	--	--	--	--	--	--	--	--
Total	8,100.00	--	2,000	1,087.50	405.00	324.00	1,816.50	126.54	121.50	248.04	2,064.54	1.0323
	[7] 9,100.00	--	4,000	1,287.50	455.00	364.00	2,106.50	253.08	243.00	496.08	2,602.58	.6506
	[7] 9,100.00	--	6,000	1,287.50	455.00	364.00	2,106.50	379.62	364.50	744.12	2,850.62	.4751

[1] Obtained from manufacturers of equipment.
[2] In accordance with U.S. Internal Revenue Service Bulletin "F" based on reasonable life expectancy.
[3] An average power rate of $0.027 per kilowatt hour, commercial power schedule. Source: Federal Power Commission statistics.
[4] Maintenance costs computed at the following percentages of initial cost when machines are used 2,000 hours per year:
1 1/2 percent-towtractor and forklift truck; 5 percent-selector truck.
Maintenance costs are doubled if the machines are used 4,000 hours per year, and tripled if used 6,000 hours per year.
[5] Power requirements for batteries computed in accordance with manufacturer's specifications using the following formula:

$$\frac{\text{(power cost)} \times \text{(kwh. battery capacity)} \times \text{(percentage of battery use)} \times \text{(percentage increase for battery efficiency)}}{\text{(charger efficiency)}}$$

$$\frac{\$0.027 \times 6.22 \times 0.80 \times 1.25}{0.75}$$

equals $0.2239, per charge per battery per day.

$0.2239 x 250 (days) equals $55.98 annual power cost for 2,000 hours of use.
[6] Price quotation for purchase in lots of 100.
[7] Electric forklift trucks which are used 4,000 or 6,000 hours per year require 2 batteries.

Table 24.--Estimated cost of ownership and operation, per machine, of warehouse equipment used in shipping produce with method B

Type of equipment	Initial cost[1]	Expected useful life[2]	Assumed use per year	Ownership cost per year				Operation cost per year			Total ownership and operation cost	
				Depreciation	Interest at 5 percent	Insurance and taxes at 4 percent	Total	Electricity[3]	Maintenance[4]	Total	Per year	Per hour
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Low-lift platform truck (4,000-pound capacity)	Dollars	Number	Hours	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Machine	1,583	8	--	197.88	--	--	--	--	--	--	--	--
Battery, 4.99 kwh capacity	635	5	--	127.00	--	--	--	--	--	--	--	--
Charger	425	8	--	53.13	--	--	--	--	--	--	--	--
Total	2,643	--	2,000	378.01	132.15	105.72	615.88	[5] 45.00	39.65	84.65	700.53	.3503
	[6] 3,278	--	4,000	505.01	163.90	131.12	800.03	90.00	79.30	169.30	969.33	.2423
	[6] 3,278	--	6,000	505.01	163.90	131.12	800.03	135.00	118.95	253.95	1,053.98	.1757
(2) Powered belt conveyor (16-inch belt)												
(a) 15-foot length. expandable to 25-feet (1-hp.)	2,201	15	2,000	147.47	110.05	88.04	345.56	50.33	33.02	83.35	428.91	.2145
	2,201	15	4,000	147.47	110.05	88.04	345.56	100.66	66.03	166.69	512.25	.1281
(b) 32-foot lenght (1-hp.)	1,618	15	2,000	108.41	80.90	64.72	254.03	50.33	24.27	74.60	328.63	.1643
	1,618	15	4,000	108.41	80.90	64.72	254.03	100.66	48.54	149.20	403.23	.1008
(3) Dictaphone	425	8	2,000	53.13	21.25	17.00	91.38	5.00	6.38	11.38	102.76	.0514
	425	5	4,000	85.00	21.25	17.00	123.25	10.00	12.76	22.76	146.01	.0365
(4) Transcriber, speakers, and controls	575	8	2,000	71.88	28.75	23.00	123.63	5.00	8.63	13.63	137.26	.0686
	575	5	4,000	115.00	28.75	23.00	166.75	10.00	17.26	27.26	194.01	.0485

[1] Obtained from manufacturers of equipment.
[2] In accordance with U.S. Internal Revenue Service Bulletin "F" based on reasonable life expectancy.
[3] An average power rate of $0.027 per kilowatt hour, commercial power schedule. Source: Federal Power Commission statistics.
[4] Maintenance costs computed at following percentages of initial cost when machines are used 2,000 hours per year:
1 1/2 percent - low-lift platform truck, powered belt conveyor, dictaphone, and transcriber.
Maintenance costs are doubled if the machines are used 4,000 hours per year, and tripled if used 6,000 hours per year.
[5] Power requirements for batteries computed in accordance with manufacturers' specifications using the following formula:

$$\frac{\text{(power cost)} \times \text{(kw.-hr. battery capacity)} \times \text{(percent battery use)} \times \text{(percent increase for battery efficiency)}}{\text{(charger efficiency)}}$$

$$\frac{\$0.027 \times 4.99 \times 0.80 \times 1.25}{0.75}$$

equals $0.180, per charge per battery per day.

$0.180 X 250 (days) equals $45.00 annual power cost for 2,000 hours of use.
[6] Electric low-lift platform trucks which are used 4,000 or 6,000 hours per year require 2 batteries.

Table 25.--Estimated cost of ownership and operation, per machine, of warehouse equipment used in shipping produce with method C

Type of equipment	Initial cost[1]	Expected useful life[2]	Assumed use per year	Ownership cost per year				Operation cost per year			Total ownership and operation cost	
				Depreciation	Interest at 5 percent	Insurance and taxes at 4 percent	Total	Electricity[3]	Maintenance[4]	Total	Per year	Per hour of use
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
	Dollars	Number	Hours	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
(1) Jack for semilive skid (3,000-pound capacity)	75.75	10	2,000	7.58	3.79	3.03	14.40	--	3.79	3.79	18.19	.0091
(2) Counterbalanced forklift truck (3,000-pound capacity)												
Machine	7,822.00	8	--	977.75	--	--	--	--	--	--	--	--
Battery, 22.92-kwh. capacity.	2,022.00	5	--	404.40	--	--	--	--	--	--	--	--
Charger	775.00	8	--	96.88	--	--	--	--	--	--	--	--
Total	10,619.00	--	2,000	1,479.03	530.95	424.76	2,434.74	[5] 206.25	159.29	365.54	2,800.28	1.4001
	[6]12,641.00	--	4,000	1,883.43	632.05	505.64	3,021.12	412.50	318.58	731.08	3,752.20	.9381
	[6]12,641.00	--	6,000	1,883.43	632.05	505.64	3,021.12	618.75	477.87	1,096.62	4,117.74	.6863
(3) Powered belt conveyor (16-inch belt)												
(a) 26-foot length expandable to 43-feet (2-hp.)	5,020.00	15	2,000	336.34	251.00	200.80	788.14	100.66	75.30	175.96	964.10	.4821
	5,020.00	15	4,000	336.34	251.00	200.80	788.14	201.32	150.60	351.92	1,140.06	.2850
(b) 90-degree curved section	1,985.00	15	2,000	133.00	99.25	79.40	311.65	50.33	29.78	80.11	391.76	.1959
	1,985.00	15	4,000	133.00	99.25	79.40	311.65	100.66	59.55	160.21	471.86	.1180
(c) 32-foot length (1-hp.)	1,618.00	15	2,000	108.41	80.90	64.72	254.03	50.33	24.27	74.60	328.63	.1643
	1,618.00	15	4,000	108.41	80.90	64.72	254.03	100.66	48.54	149.20	403.23	.1008
(d) 20-foot length (1-hp.)	1,323.00	15	2,000	88.64	66.15	52.92	207.71	50.33	19.85	70.18	277.89	.1389
	1,323.00	15	4,000	88.64	66.15	52.92	207.71	100.66	39.69	140.35	348.06	.0870
(4) Microphone, speakers, and controls	775.00	8	2,000	96.88	38.75	31.00	166.63	5.00	11.63	16.63	183.26	.0916
	775.00	5	4,000	155.00	38.75	31.00	224.75	10.00	23.26	33.26	258.01	.0645

[1] Obtained from manufacturers of equipment.

[2] In accordance with U.S. Internal Revenue Service Bulletin "F" based on reasonable life expectancy.

[3] An average power rate of $0.027 per kilowatt hour, commercial power schedule. Source: Federal Power Commission statistics.

[4] Maintenance costs computed at the following percentages of initial cost when machines are used 2,000 hours per year:
1 1/2 percent - forklift truck, powered belt conveyor, and microphone.
5 percent - jack for semilive skid. Maintenance costs are doubled if the machines are used 4,000 hours per year, and tripled if used 6,000 hours per year.

[5] Power requirements for batteries computed in accordance with manufacturers' specifications using the following formula:

$$\frac{\text{(power cost)} \times \text{(Kw-hr. battery capacity)} \times \text{(percent battery use)} \times \text{(percent increase for battery efficiency)}}{\text{(charger efficiency)}}$$

$$\frac{\$0.027 \times 22.92 \times 0.80 \times 1.25}{0.75}$$

equals $0.825, per charge per battery per day.

$0.825 X 250 (days) equals $206.25 annual power cost for 2,000 hours of use.

[6] Electric forklift trucks which are used 4,000 hours or 6,000 hours per year require 2 batteries.

Insurance and local taxes (column 7) vary widely in different regions of the United States. Four percent is assumed representative of nationwide requirements. The electricity rate of ¢ 27 per kilowatt hour (column 9) represents a national average based on a commercial power rate schedule published by the Federal Power Commission.

Maintenance costs (column 10) are given as a percentage of original equipment costs, when the equipment is used on a one-shift basis (2,000 hours per year). Cost of maintenance is doubled or trebled when equipment is used 4,000 or 6,000 hours per year. These assumptions are in accordance with equipment manufacturers' recommendations and warehouse operators' experiences.

Columns 12 and 13, the last 2 columns of the tables, show total annual and hourly costs.

Cost per year and per ton of produce shipped for pallets, and dead and semilive skids for the three methods is computed in table 26. A separate table is used because cost is based on assumed produce turnover of 80 per year, and because the number of hours of use per year for a pallet or a skid is but a fraction of the 2,000, 4,000, or 6,000 hours of assumed use for items of equipment in tables 23 through 25.

Pallets are the conventional hardwood, heavy-duty type commonly used in perishable food warehouses. Skids have a 1 1/8 inch thick hardwood deck and armored ends. Semilive skids have 8-inch diameter steel, rubber-tired wheels and a welded steel-angle frame enclosing a hardwood platform.

Table 26.--Estimated cost per year, and per ton of produce shipped, for a pallet, a dead skid, and a semilive skid, with three methods of assembling merchandise and loading trucks

Type of equipment	Initial cost[1]	Expected useful life[2]	Ownership cost per year				Operation cost per year		Total ownership and operation cost	
			Depreciation	Interest at 5 percent	Insurance & taxes at 4 percent	Total	Maintenance[3]	Total	Per year	Per ton of produce shipped
	Dollars	Number	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Pallet, 48 by 40 inches, methods A and C.....	2.80	5	0.56	0.14	0.11	0.81	0.14	0.14	0.95	[4]0.0143
Dead skid, 36 by 54 inches, method B[5].....	12.00	10	1.20	.60	.48	2.28	.60	.60	2.88	[6].0326
Semilive skid, 36 by 54 inches, method C.....	34.38	10	3.44	1.72	1.38	6.54	1.72	1.72	8.26	[7].0257

[1] Obtained from manufacturers of equipment.
[2] In accordance with U.S. Internal Revenue Service Bulletin "F", based on reasonable life expectancy.
[3] Computed at 5 percent of initial cost of equipment. Maintenance costs are doubled for receiving and shipping.
[4] Based on assumed sales of 100 tons per day multiplied by 1.67 pallets per ton (1,200 pounds) equals - 167 pallets multiplied by an assumed inventory of 4.5 days equals750 pallets required for 1,000 carlot equivalent annual sales volume. At an annual cost $.95 per pallet, total annual pallet cost will equal $712.50. With sales totaling 25,000 tons the pallet cost will equal $.0285, per ton. Pallet cost per ton is divided equally between receiving and shipping, hence pallet cost per ton for shipping will equal $.0143.
[5] Each dead skid is assumed to carry 1,600 pounds.
[6] Based on assumed sales of 100 tons per day multiplied by 1.25 skids per ton (1,600 pounds) equals - 125 skids multiplied by an assumed inventory of 4.5 days equals 565 skids for 1,000 carlot equivalent annual sales volume. At an annual cost of $2.88 per dead skid total annual cost would equal $1,627.20. With sales totaling 25,000 tons the skid cost will equal $.0651 per ton. Dividing skid cost equally for receiving and shipping, dead skid cost per ton for shipping will equal $0.0326.
[7] With method C, 14 semilive skids are used for order assembly. At an annual cost of $8.26 per skid, total annual skid cost equals $115.64. Eighteen percent of the 25,000 tons shipped, or 4,500 tons, are assembled on semilive skids. Skid cost per ton equals $.0257. Two jacks at an annual cost of $36.38 (table 25) are also used for assembly. Jack cost will total $.0081 per ton for a cost of $.0338 per ton for semilive skids and jacks. With two shifts the same number of jacks and skids will handle twice the tonnage at half the cost.

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